The Journal of Bone and Joint Surgery

The Official Publication of
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
South African Orthopaedic Association

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The Journal of Bone and Joint Surgery*

American Volume

TABLE OF CONTENTS

October 1953

PAGE

The "Unsolved" Fracture. A Protest Against Defeatism.
By *James A. Dickson, M.D.*, Cleveland, Ohio 805

The Diagnosis and Treatment of Giant-Cell Tumors of Bone.
By *Edward L. Compere, M.D.*, Chicago, Illinois 822

Chondromyxoid Fibroma of Bone. Report of Two Cases.
By *David C. Dahlin, M.D.*, Rochester, Minnesota, *Arthur H. Wells, M.D.*, Duluth, Minnesota, and *Edward D. Henderson, M.D.*, Rochester, Minnesota 831

Reticulum-Cell Sarcoma of Bone.
By *John C. Ivins, M.D.*, and *David C. Dahlin, M.D.*, Rochester, Minnesota 835

Luxatio Coxae Congenita. A Follow-up Study of Four Hundred and Six Cases of Closed Reduction.
By *Eivind Platou, M.D.*, Oslo, Norway 843

Fractures of the Hip in Children. Treatment and Results.
By *Alvin J. Ingram, M.D.*, and *Borden Bachynski, M.D.*, Memphis, Tennessee 867

Osteoid Osteoma in the Hand.
By *Robert E. Carroll, M.D.*, New York, N. Y. 888

Aseptic Necrosis of Bone in Caucasians with Chronic Hemolytic Anaemia Due to Combined Sickling and Thalassemia Traits.
By *Rudolph S. Reich, M.D.*, and *Norman J. Rosenberg, M.D.*, Cleveland, Ohio 894

Direct Surgery in Segmental Arteriosclerosis.
By *Ormand C. Julian, M.D.; William S. Dye, Jr., M.D.; William J. Grove, M.D.;* and *John S. Olwin, M.D.*, Chicago, Illinois 905

Congenital Arteriovenous Fistulae of the Hand.
By *Raymond M. Curtis, M.D.*, Baltimore, Maryland 917

Nylon Membrane Arthroplasty of the Knee in Chronic Arthritis.
By *John G. Kuhns, M.D.; Theodore A. Potter, M.D.; Robert S. Harmell, M.D.;* and *William A. Elliston, M.D.*, Boston, Massachusetts 929

The Age Incidence of Neural-Arch Defects in Alaskan Natives, Considered from the Standpoint of Etiology.
By *T. D. Stewart, M.D.*, Washington, D. C. 937

The Use of Staples and Bone-Chip Grafts for Internal Fixation in Foot-Stabilizing Operations.
By *Rufus H. Alldredge, M.D.*, and *Daniel C. Riordan, M.D.*, New Orleans, Louisiana 951

The Patellar-Advancement Operation in Cerebral Palsy.
By *W. M. Roberts, M.D.*, and *John P. Adams, M.D.*, Gastonia, North Carolina 958

(*Continued on page 3*)

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TABLE OF CONTENTS

(Continued from page 1)

PAGE

Arthropathy Due to Adjacent Inflammation.
By *Robert K. Lippmann, M.D.*, New York, N. Y. ... 967

An Experimental Study of the Use of Gelfoam to Fill Defects in Bone.
By *Fred C. Reynolds, M.D.*, and *Lee T. Ford, M.D.*, St. Louis, Missouri ... 980

Intra-Articular Hydrocortisone in Arthritis and Allied Conditions. A Summary of Two Years' Clinical Experience.
By *Joseph Lee Hollander, M.D.*, Philadelphia, Pennsylvania ... 983

Experimental Tendon Repair within the Flexor Tunnels. The Use of Hydrocortisone without Improvement of Function in the Dog.
By *Richard I. Gonzalez, M.D.*, San Francisco, California ... 991

The Use of Compound F (Hydrocortone) in Operative and Non-Operative Conditions of the Hand.
By *Lot D. Howard, Jr., M.D.; Donald Roy Pratt, M.D.;* and *Sterling Bunnell, M.D.*, San Francisco, California ... 994

Rupture of the Extensor Pollicis Longus Tendon Following Colles' Fracture.
By *Kenneth Christophe, M.D.*, Boston, Massachusetts ... 1003

Partial Rupture of the Tendon of the Posterior Tibial Muscle.
By *J. Albert Key, M.D.*, St. Louis, Missouri ... 1006

Ewing's Tumor of the Talus (Astragalus) Simulating Aseptic Necrosis.
By *Jonathan Cohen, M.D.; Kenneth A. Brown, M.D.;* and *David S. Grice, M.D.*, Boston, Massachusetts ... 1008

A Mechanical Aid to Walking. A Crab Crutch with a Universal Joint.
By *Borden Bachynski, M.D.*, Memphis, Tennessee ... 1013

Posterolateral Fusion of the Lumbar and Lumbosacral Spine.
By *Melvin Brent Watkins, M.D.*, New York, N. Y. ... 1014

A Simplified Lateral-View Cassette Holder for Use during Hip-Nailing.
By *B. R. Wiltberger, M.D.*, Columbus, Ohio ... 1018

Report of a Tour of Consultation to the Medical Installations of the Far East Command.
By *Mather Cleveland, M.D.*, New York, N. Y. ... 1020

Proceedings:
The American Orthopaedic Association ... 1027
American Medical Association. Section on Orthopaedic Surgery ... 1036

W. Eugene Wolcott ... 1041

M. N. Smith-Petersen ... 1042

John Patrick Murphy ... 1045

News Notes ... 1046

Announcement ... 1048

Index to Volume 35-A
Authors ... 1049
Subjects ... 1055
Books Reviewed ... 1097

Addresses of Contributors ... Cover III

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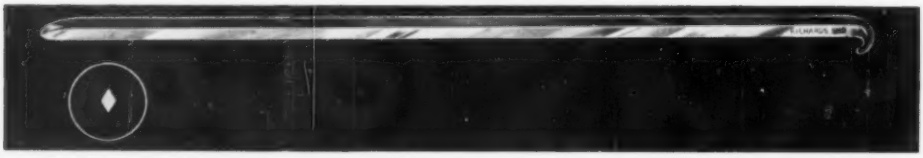

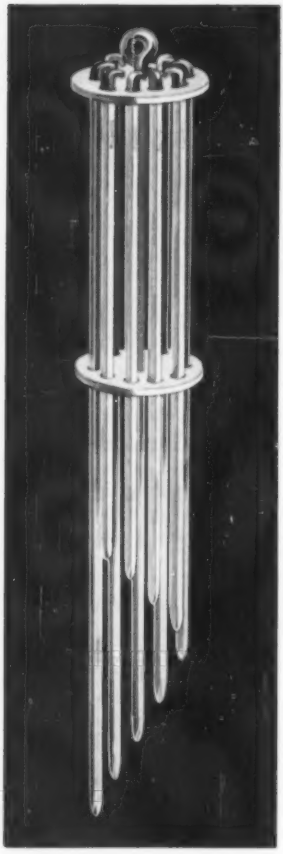

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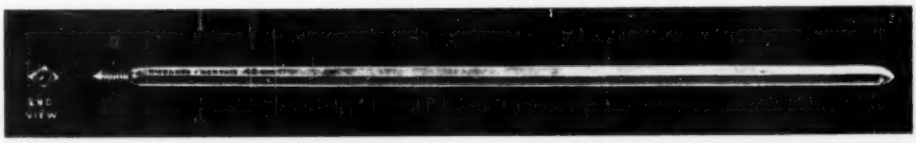

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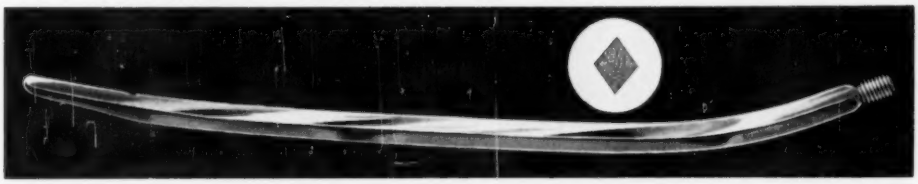

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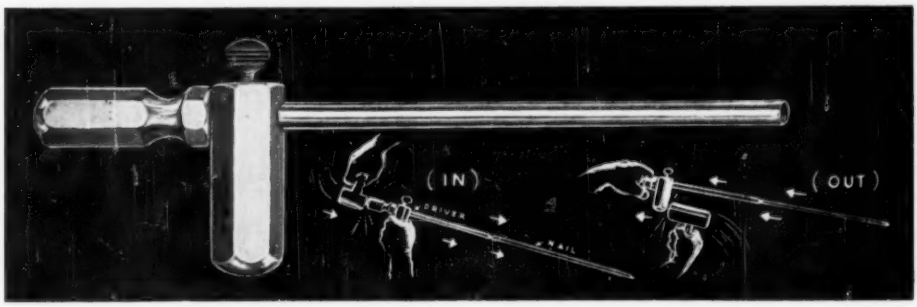

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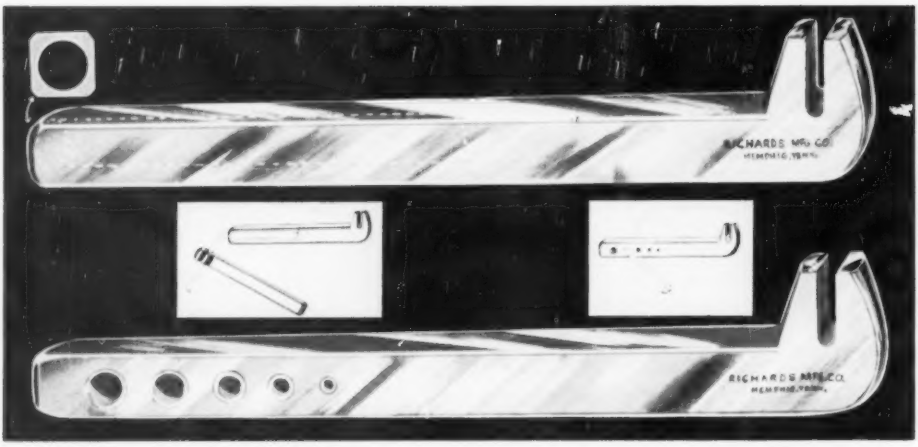

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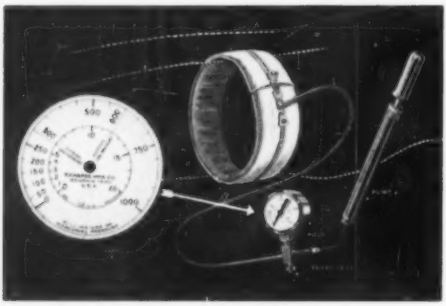

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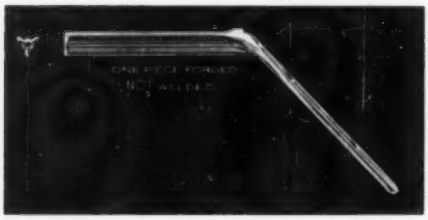

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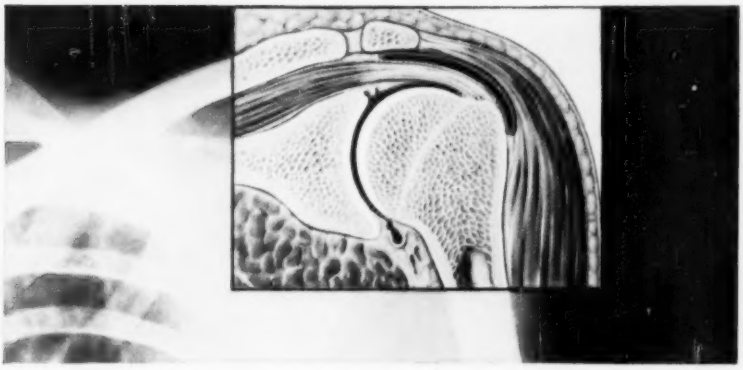

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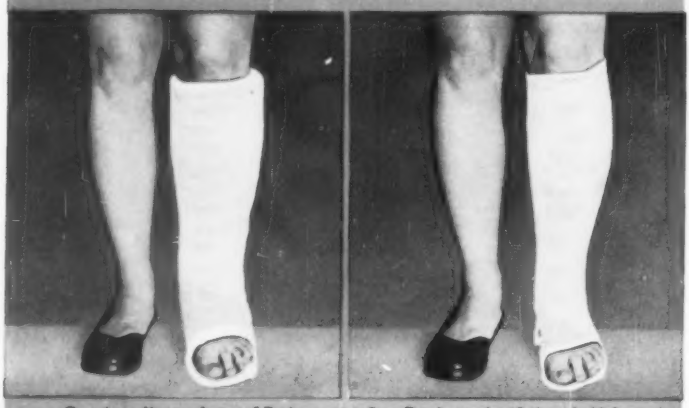

Cast A—ordinary plaster of Paris — **Cast B, *plaster fortified with Melmac*, is half thickness of cast A and weighs less**

6 great advantages of casts made with Melmac Orthopedic Composition

1. *Four times the early strength* and over twice the dry strength of ordinary plaster of Paris casts.
2. *Lighter, thinner and stronger casts* provide added comfort and support.
3. *Water and urine resistant.* Does not disintegrate even after several days soaking.
4. *Permits better x-ray penetration* due to thinness of cast.
5. Economical—*50% fewer bandages or less needed;* saves the doctor time.
6. *Conveniently packaged* to permit using as much or as little as is needed for a given case, avoiding waste.

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Sutures and other surgical specialties

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Use of Melmac requires no new technique

To use bandages and splints wetted with Melmac solution, no new technique for applying casts need be learned. Plaster rolls or splints are soaked in the Melmac solution in the usual manner, the excess solution is pressed out, and the cast applied with the same technique as with ordinary plaster bandages and splints.

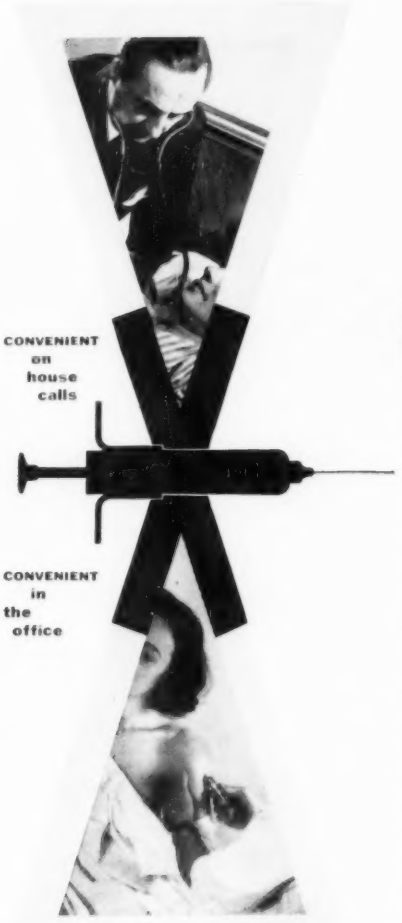
Note:

Cobey,[3] reports not one person allergic to Melmac in applying 1000 casts.

references:

1. A. W. Spittler, Col., (M.C.), U.S.A., J. J. Brennan, Lt. Col., (M.C.), U.S.A., J. W. Payne, Capt., U.S.A.F. (M.C.), American Academy of Orthopedic Surgeons, Jan. 26-31, 1952, Chicago, Illinois.
2. M. C. Cobey, M.D., F.A.C.S., Professor of Orthopedic Surgery, Georgetown University and Senior Attending Orthopedic Surgeon, Children's Hospital, Washington, D.C., The American Surgeon, Vol. XVIII, No. 4, April, 1952, pp. 413, 415.
3. M. C. Cobey, M.D., F.A.C.S., Washington, D.C., private communication.

Davis & Geck manufactures a complete line of surgical sutures. Diameter for diameter, the tensile strength of D&G Surgical Gut is unexcelled by any other brand.



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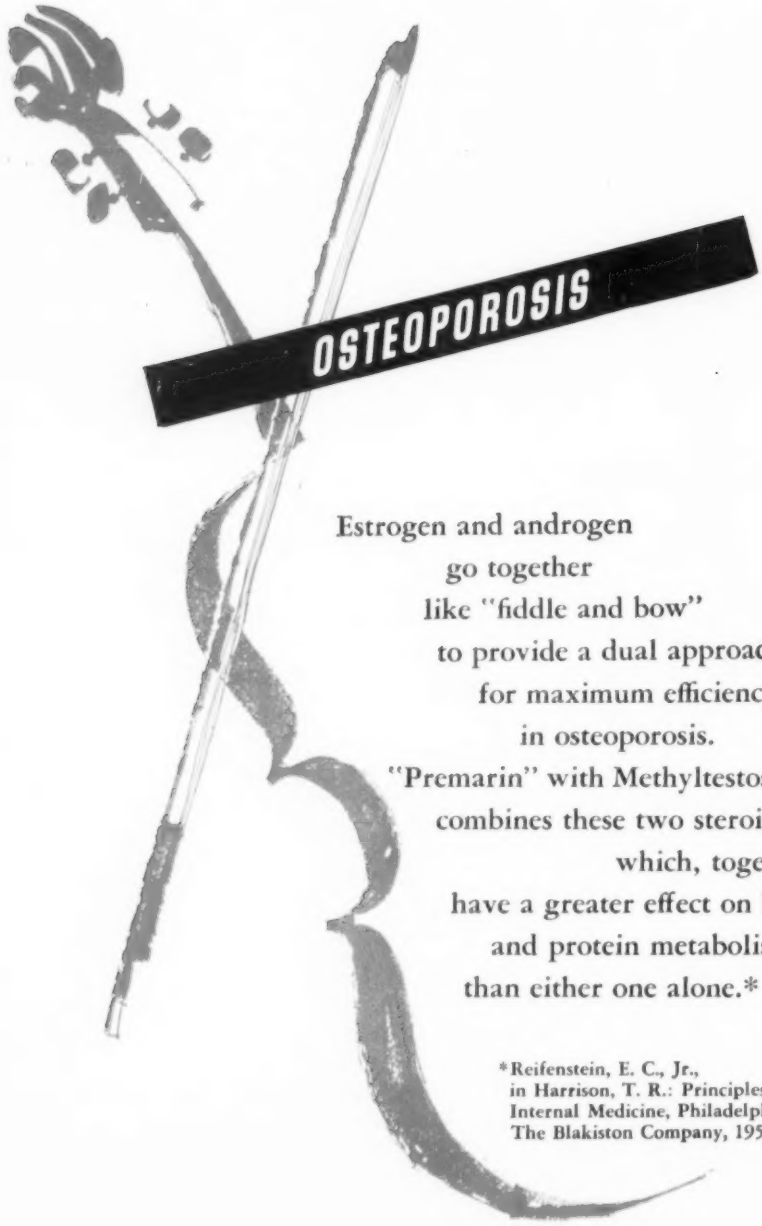

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which, together,
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*Reifenstein, E. C., Jr.,
in Harrison, T. R.: Principles of
Internal Medicine, Philadelphia,
The Blakiston Company, 1950, p. 655.

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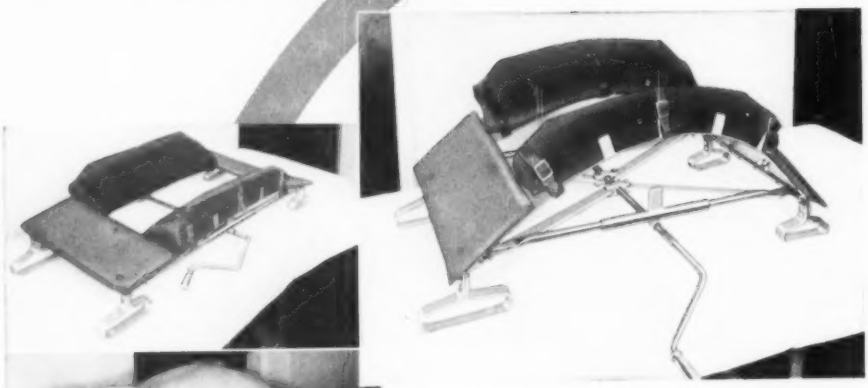
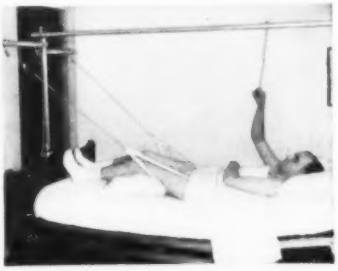


No. 551 Wilson Convex Frame for Spinal Surgery. Positions patient with spine in flexion and with no pressure on abdomen. Adjustable during surgery.



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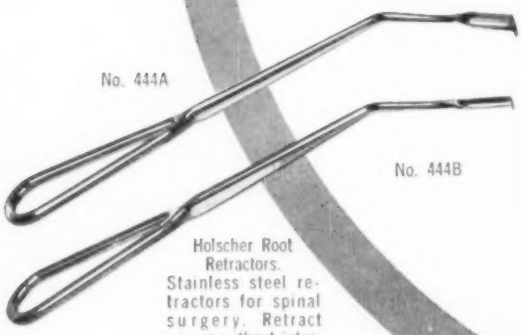

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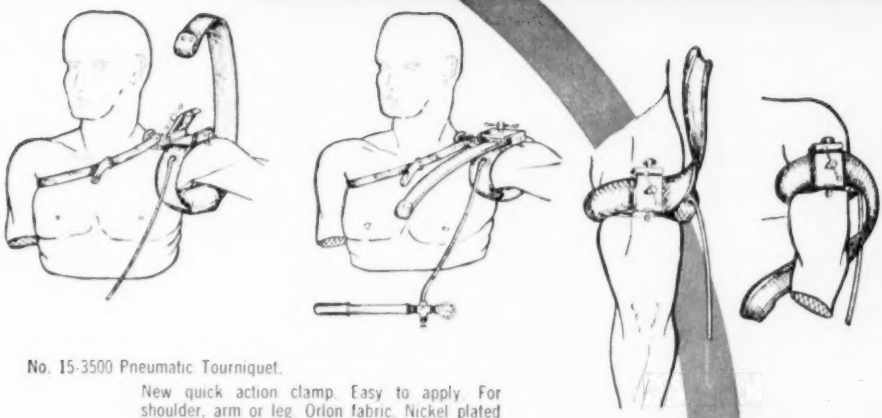

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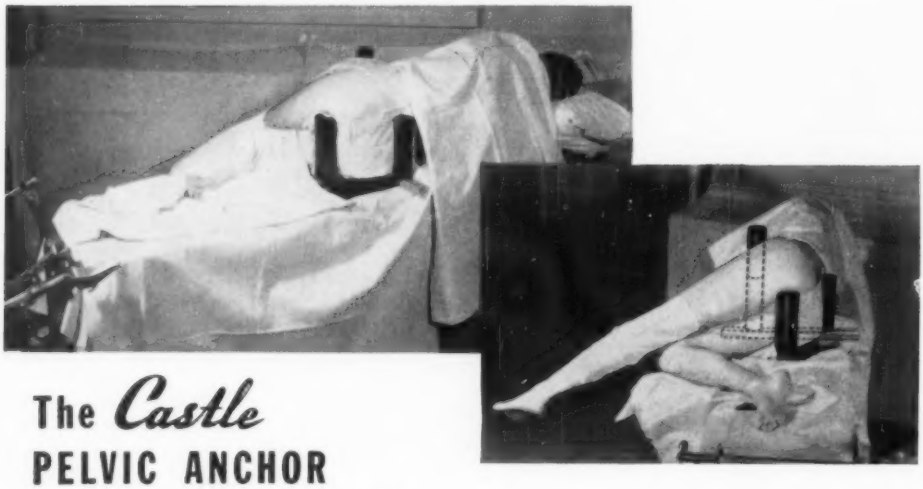
in Lateral Position

Simplifies clinical approach in arthroplasty, hip prosthesis, and thoracic surgery



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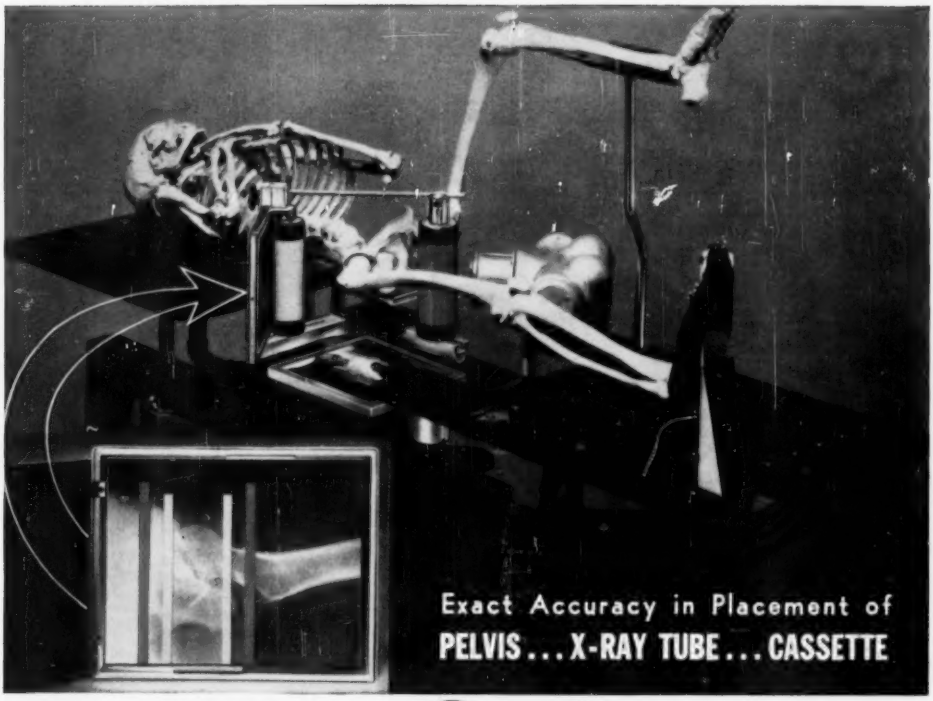

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Demonstrates Alignment in Lateral View

- Mechanics of the CASTLE PELVIC ANCHOR permit patient's pelvis to be anchored to the table in the same identically related position . . . as often as required.
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- All standard makes of orthopedic tables may be equipped with the Castle Pelvic Anchor Sacral Rest for positive pelvic anchorage and accurate radiography.

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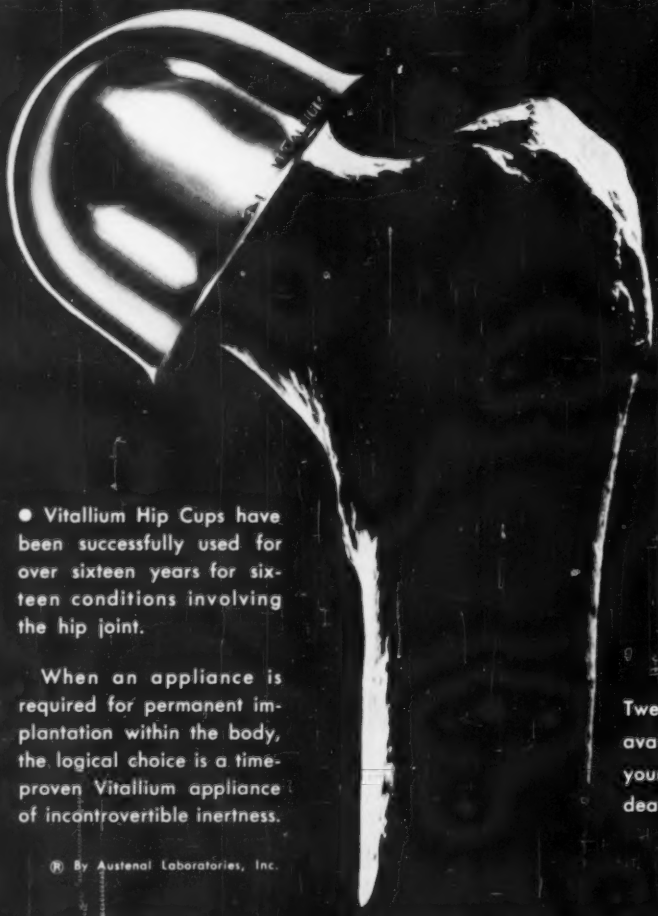

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References: "Internal Contact Splint" —Eggers, G.W.N.
Jour. Bone & Joint Surg., 30-A, No. 1, Jan. 1948
"The Influence of The Contact-Compression Factor on Osteogenesis in Surgical Fractures" — Eggers, G.W.N., Shindler, T.O. and Pomerat, C.M.,
Jour. Bone & Joint Surg., 31-A, No. 4, Oct. 1949

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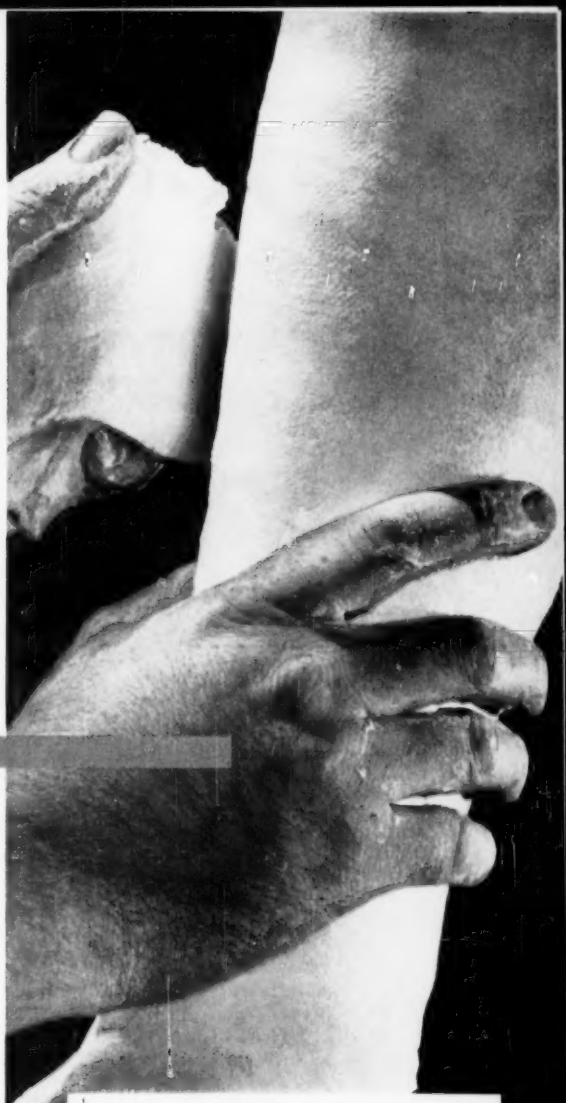

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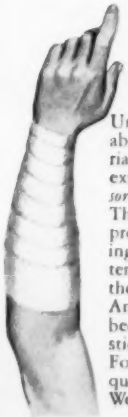

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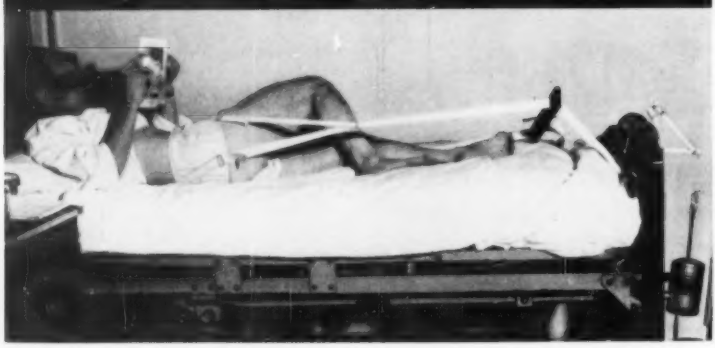

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for adults and children . . . an improved method of pelvic traction therapy for home or hospital

indicated in: 1. Prolapse of lumbar disc. 2. Herniation of lumbar disc. 3. Sprain of lower back. 4. Spondylisthesis. 5. Osteo-arthritis of lower back. 6. Acute scoliosis. 7. Fracture of lumbar vertebrae or processes. 8. Myositis, fibrositis, fascitis of lower back. 9. Injury to lower back following difficult confinement. 10. Simple fractures of pelvic bones.

advantages: 1. Effective traction. 2. Early relief from pain. 3. Permits proper nursing. 4. No complications. 5. No contra-indications. 6. Easily applied. 7. Patients cooperate.

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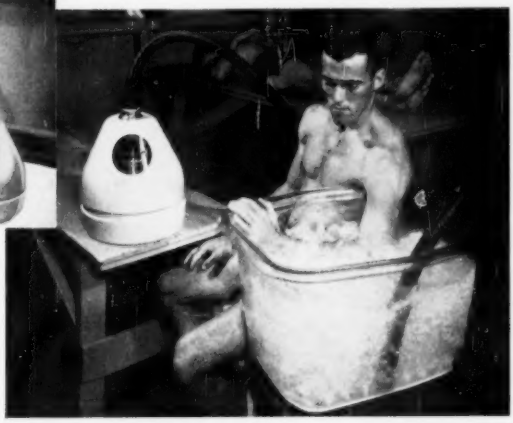

The Vibra-Bath quickly promotes circulation through the hydropercussion of thousands of warm air bubbles impinging upon every square inch of the area under treatment. It is well adapted to the treatment of sprains and injuries common to the athletic field.

In addition to the excellence of its hydromassage, the Vibra-Bath has the important advantages of light weight and easy portability. Write for illustrated brochure and HANDBOOK ON HYDROMASSAGE.

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Polished aluminum—well padded—four adjustable turnbuckle posts maintain position and traction desired—two lock nuts assure positive locking position. Sizes: small, medium and large.

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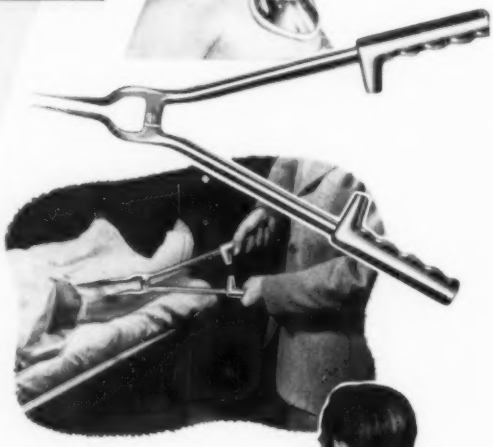
Manufactured from high grade steel forging finished in copper nickel chrome with buffed aluminum handles. Length: 18" overall. Designed for maximum leverage, greatly facilitates cast removal.



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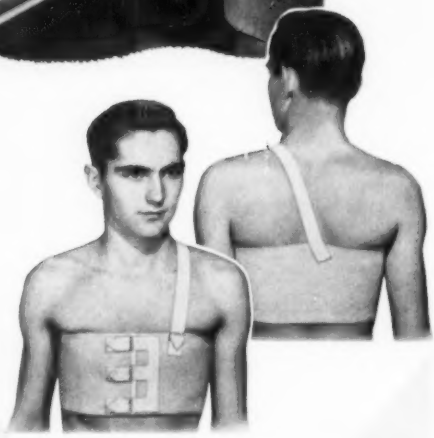
All elastic—6" wide, one soft webbing shoulder strap, 3 adjustable straps with safety buckles for front closing and adjustments. Male type sizes 26" to 48" (chest measure). Female type 26" to 46".



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15 mg. and 20 mg.
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Also available as
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Red Cross ELASTIKON Tape

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ELASTIC
—provides correctly directed support. Stays where applied, molds itself to the body — its stretch and pliability permit form-fitting bandaging.

GREATER COMFORT
— offers patient comfort and reduction of mechanical skin irritation. Encourages natural healing and tissue growth.

1" contains	12 cuts to the roll
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No connection with the American National Red Cross

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PIGEON-TOE SHOE

Carried both White Elk and Tan Elk

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Dotted line shows outline of normal shoe.

The Pigeon Toe Shoe carrying a definite outflare, is used on cases where there is an extreme toeing-in (i.e., walking pigeon-toed) and is known and called by the medical profession as a metatarsus varus deformity.

Infants' White Elk	Sizes 4½ to 8, B & EE Sizes 2½ to 8, D
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Ossacryl Femoral Head with Skirt-Extension for Short Stumps—Cat. No. P1850

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SPECIALLY DESIGNED JUDET INSTRUMENTS AND ACCESSORIES CAN BE USED WITH EITHER OSSACRYL OR METAL HEADS

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Ossacryl Humeral Head Hicks Type—Cat. No. P1914

* Neutralite is our Registered Trademark for a non-toxic and inert cobalt-base alloy containing chromium and molybdenum

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YOU can depend on KLEISTONE technicians and modern laboratory facilities to fulfill your most exacting prescriptions with scrupulous care. Our complete services include distribution, without cost, of Record Charts with special sensitized paper for actual foot impressions.

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Established 1919
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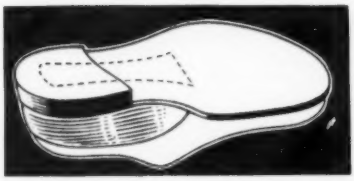
You'll be glad to prescribe Alden-Pedic shoes

Alden-Pedic
SCIENTIFIC CONSTRUCTION

- Long inside counter
- Heavy gauge ribbed steel shank
- Right and left angled heels, long inside
- Patented bottom filler prevents insole lumping

FOR MEN and BOYS



Alden-Pedic lasts are designed to accommodate your prescribed corrections and insertions. Extreme sizes stocked. Many styles available. Top quality only.

Alden-Pedic lasts and shoes have been scientifically designed and tested to accommodate specific and general degrees of foot disabilities. Doctors who become familiar with the functional merit of this program will be glad to prescribe these shoes as a foundation in the treatment and correction of foot disabilities. We do not claim that these shoes will correct abnormal foot conditions, but they will provide the types of basic footwear necessary as a foundation in aiding foot trouble and in offering foot comfort. We know you will be glad to recommend them.

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Vitamins alone are not always enough

Based on the well recognized concept of interrelationship in nutrition, "Clusivol" Capsules offer an extensive formulation of vitamins, minerals, and trace elements . . . factors likely to be lacking when restrictive diets are prescribed.

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GERIATRIC DIETS
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2 "Clusivol" Capsules (average daily dosage) provide:

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Vitamin D (irradiated ergosterol)	2,000	U.S.P. Units
Vitamin C (ascorbic acid)	150.0	mg.
Thiamine HCl (B_1)	10.0	mg.
Riboflavin (B_2)	5.0	mg.
Pyridoxine HCl (B_6)	1.0	mg.
Panthenol, equivalent to of calcium pantothenate	10.0	mg.
Vitamin B_{12} U.S.P. (crystalline)	2.0	mcg.
Folic acid	2.0	mg.
Nicotinamide	100.0	mg.
Vitamin E (as mixed tocopherols natural)	10.0	mg.
Inositol	30.0	mg.
Choline—from choline bitartrate	30.0	mg.
Biotin	0.1	mg.
d-Methionine	20.0	mg.
Cobalt—from cobalt sulfate	0.1	mg.
Copper—from copper sulfate	1.0	mg.
Fluorine—from calcium fluoride	0.025	mg.
Iron—from 4 gr. ferrous sulfate exsic.	76.2	mg.
Calcium—from dicalcium phosphate	165.0	mg.
Manganese—from manganous sulfate	1.0	mg.
Iodine—from potassium iodide	0.15	mg.
Molybdenum—from sodium molybdate	0.2	mg.
Potassium—from potassium sulfate	5.0	mg.
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Multiple vitamin-mineral supplement

No. 293—Supplied in bottles of 100 and 1,000.

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especially developed for

Low-Back Syndrome

by

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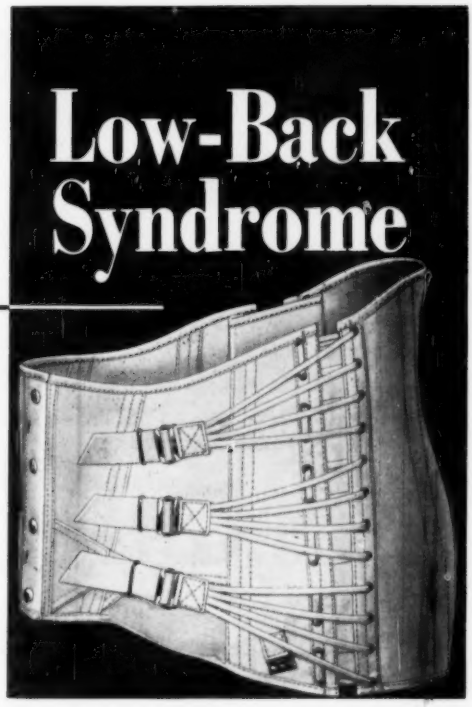

MODEL 430 EHS

- Lumbo-sacral support incorporating traction and two-semi rigid steels. Three pull straps control traction; upper straps control lumbar region support, lower strap (attached to uplift panels in front) controls traction through trochanter area, increases lower abdominal support.

The complete line of TRUFORM Anatomical Supports includes a wide selection of lumbo-sacral garments. TRUFORM Lumbo-Sacral Supports are designed, under professional supervision, for a variety of conditions generally characterized by low back pain. Such TRUFORM supports are generally used for mild lordosis or spondylolisthesis and all provide effective fixation of the lower spine, varying in degree according to the depth of the garment.

These and other TRUFORM supports are available to your patients only through *surgical or prosthetic supply houses or orthopedic dealers*. Thus your patient is assured of professionally correct fitting by a trained technician.

For descriptions and illustrations of the complete TRUFORM line write for the TRUFORM Red Book, the profusely illustrated catalog which will serve as a valuable reference.

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C-41 Cervical Appliance

Cooler	More Comfortable
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Odorless	Completely Washable
Easier to Apply	Interchangeable Parts
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model C-41*

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Order a set for inspection today! No obligation if returned within 10 days. Net 30 days.

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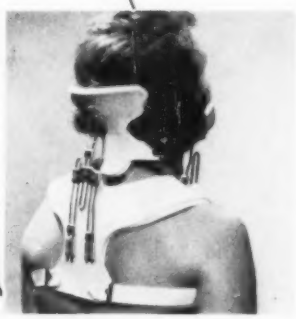

** Patent Applied For*

STANDARD BLADES

Bone Scoop
No. 1004-100.

Large sectioned blade
No. 1002-100.

Small sectioned blade
No. 1002-101.

Adjustable twin blade No. 1003.

End Cutting blade
No. 1002-200.

Arbor only
No. 1002-A.

Stryker

presents a Combination Bone Saw and Dermatome in One Precision Instrument

The Stryker Bone Saw is simple, safe and efficient to operate. Oscillating at 28,000 strokes per minute, the saw cannot catch in drapes or sponges, nor throw blood. Equipped with five blades. Adaptable to many varieties of bone surgery. Saw blades can be changed quickly during operation.

Complete with aluminum carrying case and five different blades. Specify 110 or 220 volts. Either model operates on AC or DC. Both instruments with all accessories are easy to sterilize-autoclave or boil.

The Stryker Dermatome-Bone Saw combination gives you a new convenience in skin grafting. Cuts grafts in 2⅜" strips, any thickness, any length, from any part of the body. Works most efficiently when used with transparent Stryker Skin Tape. Sewing is not always required. Skin retains its original tension.

Includes Dermatome complete with blade, thickness gauges and supply of Stryker Skin Tape, plus bone saw, five blades, blade-holder, foam rubber-lined aluminum carrying case. Specify 110 or 220 volts. Either model operates on AC or DC.

SPECIAL BLADES AT EXTRA COST

Deep cutting blade, wide
No. 1002-106

Deep cutting blade, narrow
No. 1002-107

Iliac graft cutting blade
No. 1002-103

Small bone cutting blade
No. 1002-102

Long Arbor
No. 1002-B

Orthopedic

ORTHOPEDIC FRAME COMPANY
Dept. B Kalamazoo, Mich.

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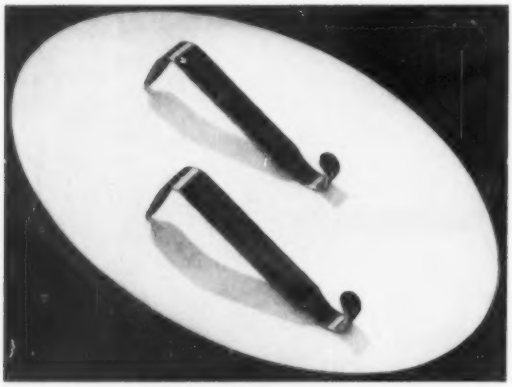


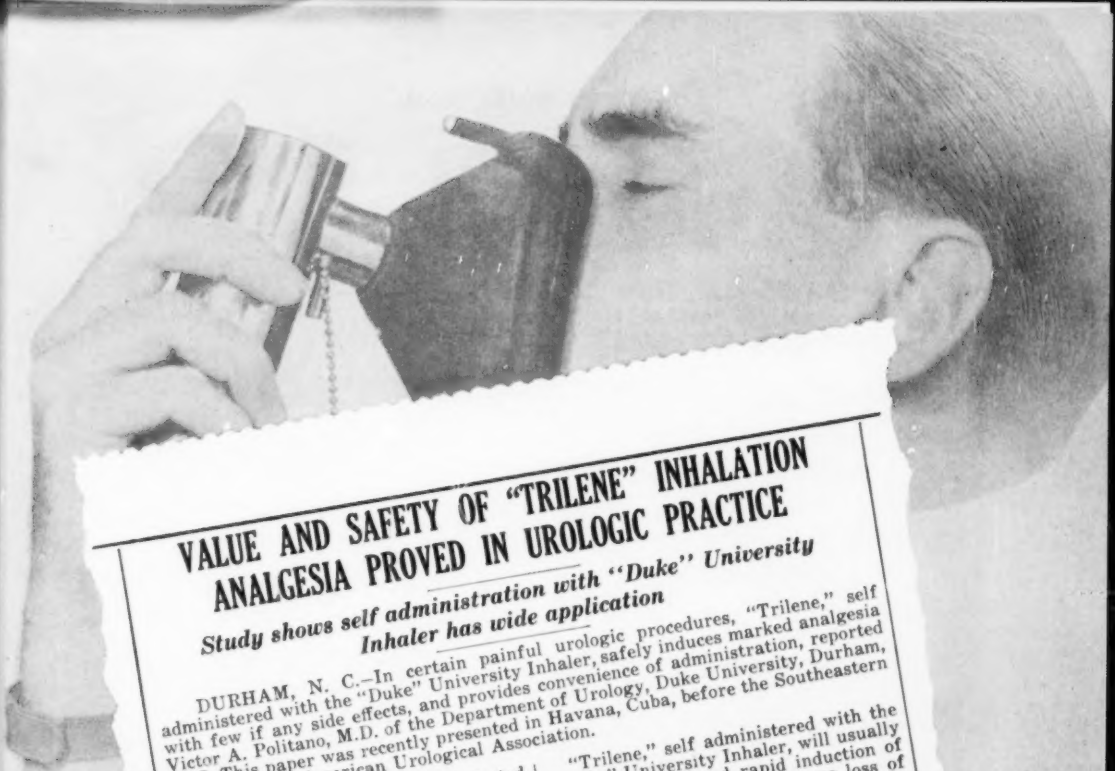
New & Simple

Taylor Spinal Retractor

This instrument has proven very effective when large muscle masses must be retracted in the lumbar region for arthrodesis and laminectomy. Leverage rather than direct pull is used to effect the retraction. *Set of two $11.00*

MEDICAL RESEARCH SPECIALTIES, Loma Linda, California

NEUFELD FEMORAL NAIL PLATE
Used for internal fixation of intertrochanteric and subtrochanteric fractures.
Write for descriptive literature
MEDICAL RESEARCH SPECIALTIES
Loma Linda, California



VALUE AND SAFETY OF "TRILENE" INHALATION ANALGESIA PROVED IN UROLOGIC PRACTICE

Study shows self administration with "Duke" University Inhaler has wide application

DURHAM, N. C.—In certain painful urologic procedures, "Trilene," self administered with the "Duke" University Inhaler, safely induces marked analgesia with few if any side effects, and provides convenience of administration, reported Victor A. Politano, M.D. of the Department of Urology, Duke University, Durham, N. C. This paper was recently presented in Havana, Cuba, before the Southeastern Section of the American Urological Association.

In over 100 cases, specially selected because a customarily painful or difficult diagnostic or therapeutic procedure was anticipated, and because "general anesthesia or heavy sedation was not practical or advisable," results with "Trilene" analgesia were described as excellent in 79 cases, and good in 28.

Stressing the need for patient cooperation and induction of adequate analgesia, Dr. Politano said "The occasional failures encountered have been due to improper or insufficient instruction in the use of the inhaler and hurried instrumentation before proper analgesia."

These findings add further support to the extensive clinical evidence of effectiveness and safety of self-administered "Trilene" analgesia in obstetrics, as well as in surgical procedures such as the reduction of fractures, incision and drainage of abscesses, removal of painful dressings.

"Trilene," self administered with the "Duke" University Inhaler, will usually provide smooth and rapid induction of analgesia with minimum or no loss of consciousness. Unconsciousness automatically interrupts inhalation. Recovery is rapid, and nausea and vomiting rarely occur.

"Trilene" is nonexplosive, and in the mixtures employed clinically is noninflammable in air and oxygen. "Trilene" may also be used as an analgesic adjunct while light planes of anesthesia are maintained with various anesthetic agents.

"Trilene,"® brand of highly purified trichlorethylene (Blue), is supplied in containers of 300 cc.

Further information on "Trilene" or the "Duke" University Inhaler (Model-M) may be obtained by writing to Ayerst, McKenna & Harrison Limited, 22 East 40th Street, New York 16, N. Y.

5332

"DUKE" University Inhaler (Model-M)

Recommended for use with "Trilene" in obstetrics and surgery, the "Duke" University Inhaler is specially designed for economy, facility of handling and ready control of vapor concentration. It can be operated with ease and efficiency by adult or child in the doctor's office, in the hospital, in industrial dispensaries, in the home, or even enroute to the hospital.

Ayerst, McKenna & Harrison Limited • New York, N. Y. • Montreal, Canada

LOTTES TIBIAL NAIL

LOTTES TRIFLANGE TIBIAL NAIL
Tibial Nail diameters: 5/16" and 3/8"

DRIVER AND EXTRACTOR

18-8 SMo Stainless Steel nail made in ½ inch lengths from 9 to 14½ inches.

The triflange nail is also available for femur, humerus, radius, and ulna.

The driver and extractor can be used with any of the triflange nails.

COMPOUND FRACTURE WHICH WAS DEBRIDED, CLOSED, AND PLACED IN CAST ON ADMISSION

RESULT THREE MONTHS AFTER PRIMARY HEALING OF WOUND AND CLOSED NAILING

For further information, please write to

CHAS. A. SCHMIDT SURG. INST. CO., ST. LOUIS 8, MISSOURI
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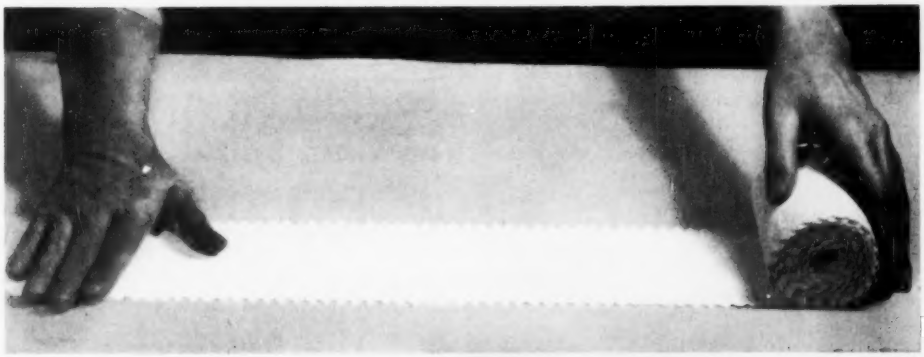
In answering advertisements, please mention *The Journal of Bone and Joint Surgery.*

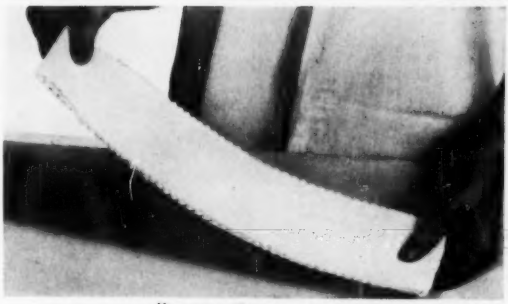
Use KARMAC *for*

PLASTER CASTS THAT ARE HARD, LIGHTWEIGHT, ECONOMICAL AND EASILY APPLIED



KARMAC plaster of paris bandages and splints have been used exclusively for the past decade by surgeons who like the creamy smoothness and hard setting qualities of this special made product. And, it actually costs less.

All Karmac bandages and splints are made entirely by hand... they contain no chemical or foreign ingredient to weaken the hard setting qualities of this finest of surgical plaster of paris.



Karmac splints are made in 5 ply and 6 ply thicknesses. They come ready to pass through water and apply.

Available in both fast-setting and slow-setting time. All sizes from 2″ to 8″ widths. Splints are 3″ x 15″ — 5 ply, 4″ x 15″ — 5 ply, and 5″ x 30″ — 6 ply.

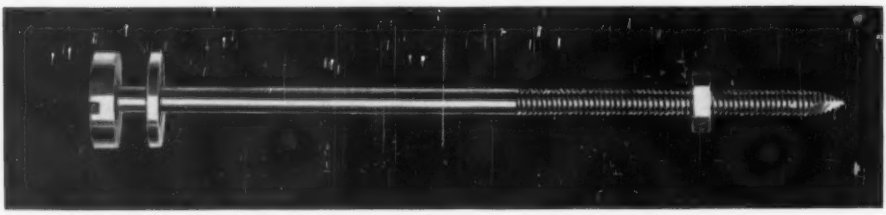
For an especially hard, lightweight cast that requires fewer bandages, order KARMAC plaster of paris bandages and splints.

If your dealer cannot supply you with Karmac, send in your order direct.

The **KARMAC** *Company*

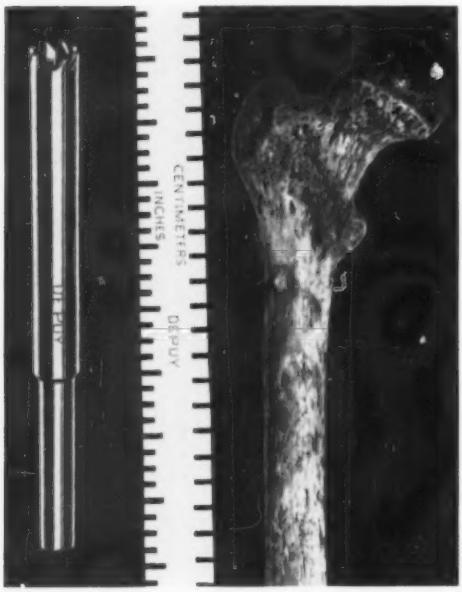
P. O. Box 2041 Dallas, Texas

Aids for the Fracture Surgeon



No. 534 Norman Tibia Bolt

⅛″ diameter, lengths 3″ — 3½″ — 4″, a tibia bolt with a slotted head. Can be inserted with a screw driver. Each bolt supplied with a washer and nut.



Screw Retrievers

For removal of broken bone screws. These retrievers fit over broken screw and quickly cut away the bone around it. You merely lift out the broken screw and insert size larger.

The Knotched Ruler

Tells you the length intermedulary nail to use exactly in inches and centimeters. Special notching makes it easy to read in X-Ray.

Write for complete information and FRACTURE CATALOG

De Puy MANUFACTURING CO., INC.
WARSAW, INDIANA

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NEWS ABOUT A BAUER & BLACK PRODUCT

Only ONE of these elastic bandages lets you control the pressure

It's TENSOR Elastic Bandage because it's woven with live rubber threads

Tensor Elastic Bandage, as the photo clearly shows, has *twice* the elasticity of ordinary old-style all cotton bandages—and it snaps back all the way. Naturally—Tensor is woven with live rubber threads—not just cotton.

That's why Tensor enables you to apply *low* pressure as easily as higher pressures.

Pressure is *uniform*—with less danger of hyperconstriction—more comfort, more mobility for patients.

And you don't have to adjust Tensor as swelling goes up or down. Tensor adjusts itself.

You, doctor, not the bandage, control pressure—when it's a Tensor.

TENSOR®

ELASTIC BANDAGE

Woven with live rubber threads

BAUER & BLACK

Division of The Kendall Co.
309 West Jackson Blvd., Chicago 6, Ill.

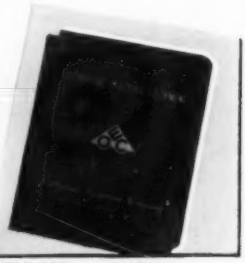
Under equal tension,
Tensor stretches approximately twice as far as old-style cotton bandages. And Tensor will snap back smoothly to its original length. That's why Tensor gives you greater control of pressure, requires no adjustment, is more comfortable to wear.

YOUR ASSURANCE OF THE FINEST OF INTERNAL FIXATION APPLIANCES

If we could conduct you on a tour through our several plants—and we would welcome the opportunity—you would find that Orthopedic Internal Fixation Appliances are made the way you would make them.

All metals used in the manufacture of internal appliances are checked to insure that they are the correct grade of SMo Stainless Steel—every machining operation employs modern techniques—careful finishing implies a knowledge of the end use of these products.

Orthopedic offers quality products available through your most convenient and natural source of supply—your nearby surgical supply dealer.



Send for your copy of our NEW 132 page catalog. Describes our broad line of splints, instruments, litters, crutches, hospital beds and other essential equipment.

Orthopedic EQUIPMENT CO.

200 Fort Wayne St., Bourbon, Indiana

For Successful Restitution

Perfection of Articulation assured because full-size head is accurately positioned by co-axial alignment within the acetabulum.

Effective Utilization of Acetabulum Assured through use of unique acetabular gauge and of our co-axial socket reamers.

Restore Length to minimize limp by use of standardized neck sections of suitable thicknesses.

Full Utilization of Weight-Bearing Capacity of faced neck and strong medial cortical column assured because of broad, flat under-surface of head.

Hollow Stainless Steel
Tremendously strong but weighs less.
No welding, riveting, or other foreign materials.

Perfect Fit Assured because full-depth and full-width heads are available in all diameters from 38 through 56 millimeters.

Sturdy Support by Calcar is assured by routine use of throat section to establish and maintain this dependable support.

a-b-c Support is Triple-Safe because the stress is carried by the three regions of the femur which normally support the weight: the calcar, the medial cortical column, and the strong lateral cortex.

Fits Any Size Patient because unique tube cutter cuts the stainless steel shaft to precise length right in surgery.

Perfection of Placement assured by use of the simple and accurate guide-pin technic.

Neck Absorption Automatically Corrected by smooth, round rotatable pedicle . . . affording the strong near-vertical support so necessary for lasting results.

USE THE TOWER FEMORAL PROSTHESIS

Now Available in Hollow Stainless Steel

The TOWER COMPANY, Inc.

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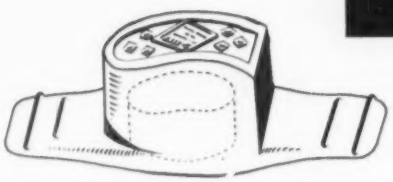

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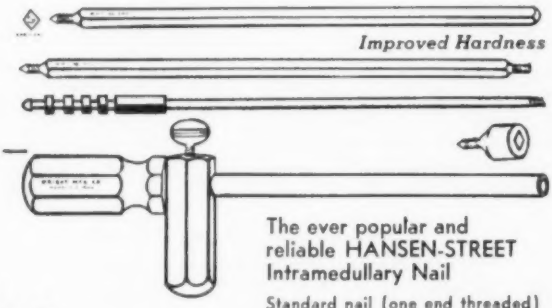

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The Journal of
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American Volume

THE "UNSOLVED" FRACTURE

A Protest Against Defeatism *

BY JAMES A. DICKSON, M.D., CLEVELAND, OHIO

During my military service in India in World War I, I had the good fortune to be stationed where I could see snow-capped Mount Everest, towering in all its majesty above the Himalayas. Hence, ever since 1924, when Mallory and Irvine made their heroic attempt to reach the summit, I have followed with more than ordinary interest the accounts of the various expeditions which have set out to conquer this highest peak. I was reading about one of these attempts at about the same time I heard our good friend and member, Dr. Kellogg Speed, give a lecture on the intracapsular fracture of the neck of the femur, which he referred to as the "unsolved" fracture. Since that time the unconquered summit of Mount Everest and the "unsolved" fracture have always been associated in my mind. Their histories during the past thirty years have run a somewhat parallel course. In that period, eleven teams tried to conquer the mountain. Some came nearer to their goal than others, but ten of them had to admit defeat. Just last year, the attempt made by a Swiss expedition failed again. Nevertheless, on the eleventh attempt, the British expedition made the successful assault on this formidable peak a few weeks ago, and the ingenuity and perseverance of man once more registered a victory over one of the challenges of nature.

I wish that what I have to say about intracapsular fractures of the femur could register the same sort of victory over the "unsolved" fracture. That is impossible, for complete success in the solution of this problem is yet to come. Nevertheless, in our various attempts to conquer the difficulties, we have learned much and have made great progress, I believe; and we are nearing the time when we shall achieve the satisfactory results for which we have been striving. The Hillary and the Tensing of the "unsolved" fracture may well be in this audience today. I do not feel that I am overconfident in predicting that the pinnacle can be reached, and it is my hope that my presentation here this morning may stimulate many of you to take heart and "climb" again.

You may be familiar with the answer that the inimitable Mortimer Snerd gave to Edgar Bergen when the latter asked him, "If at first you don't succeed, what do you do?" Instead of giving the expected reply of "Try, try again", Mortimer said, without a moment's hesitation, "Why, I just give it up".

It seems to me that many surgeons in our specialty are emulating Mortimer Snerd and assuming a defeatist attitude in regard to the treatment of transcervical fractures of the femur. This attitude is characterized by a passive acceptance of our present method of treatment of fresh fractures as the ultimate, by failure to make a continued effort to procure union and subsequent vascularization, and by sacrificing the head of the femur and substituting a prosthesis.

* Presented as the President's Address at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 30, 1953.

I protest against such defeatism, because I believe that, if emphasis is placed on the early treatment with the purpose of obtaining normally functioning hips, and if secondary procedures are performed promptly as soon as they are indicated, the majority of the complications we now see would not arise, and the need for reconstructive operations and prosthetic replacements would be drastically reduced. In saying this, I do not mean to imply that there is no place for the prosthetic replacement. It will find its place just as arthrodesis and other reconstructive measures have, but like these procedures, it should be reserved for those fractures which have failed to respond to the best techniques, applied in accordance with basic principles, which we have at our disposal today.

In my opinion, the use of a prosthesis in fresh fractures is to be deplored except in certain unusual circumstances, as, for example, in the case of a very old or bedridden patient, when the treatment of choice is that which will produce a painless joint not necessitating normal function. It has yet to be shown that a patient with a prosthesis walks as well or has a permanent result as satisfactory as does the patient in whom the normal architecture of the hip has been preserved. Furthermore, the use of metal and acrylic substitutions is far from being without risk, as was emphasized by the report on prostheses given at the meeting of the Academy last January. This report * analyzed the answers to a questionnaire by 466 surgeons who had used prostheses on a total of 6,156 patients who had been followed for an average period of ten months. In this group of 466 surgeons, 158 men reported that they had observed dislocations; eighty had had trouble with infections; eighty had had fractures of the shaft or trochanter; and seventy-five reported that the patients complained of pain after operation. Only eight of the 466 men who replied to the questionnaire said that they had encountered no complications.

The taking of the risk implied in such statistics as these may be justifiable in those fractures that have failed to respond to the best methods and principles at our disposal—and there are always some that do fail—but it would appear that it is definitely contra-indicated to subject a patient to such hazards by using a prosthesis in an acute fracture until a concerted effort has been made with other measures.

In acute fractures, the remaining circulation in the head fragment varies considerably, depending on the location of the transcervical break. Whether the head portion is only partially or completely separated from its circulation and whether the head fragment partially or completely dies, it can be vascularized or returned to normal by creeping substitution and revascularization. These processes will take place under favorable circumstances. It is our duty to provide these favorable circumstances or at least to strive for their accomplishment. Much more can be done in this regard than is being done today, if we use more aggressive means in our treatment of non-union at its earliest stage.

Before we "just give it up" and take the defeatist attitude that the intracapsular fracture of the femoral neck is not only "unsolved" but insolvable, let us pause and review what has been accomplished in its treatment during the last five decades. It is important that we know the beginnings, the struggles, and the improvements.

Before the turn of this century, it was the vogue to "treat the patient and let the fracture go", following the thesis of Sir Astley Cooper that "fractures of the neck of the femur internal to the capsular ligament do not unite by bone". This was the period of so-called willful or judicious neglect. After 1900 this pessimistic dictum was refuted, with a consequent revision in thinking in regard to transcervical fractures of the femur, by the works of two great teachers. Gurlt, an eminent German pathologist, stated: "Old age does not retard the progress of union, as has been erroneously supposed; reparative processes remain the same during adult life". Senn, in 1901, reaffirmed and emphasized this basic truth, when he stated: "There is no specific tendency to non-union in any form of fracture. If the ends of the bone can be kept in perfect apposition, union by bone will take place", and he added further, "We are not only justified but warranted in asserting

* Preliminary Survey on Femoral-Head Prostheses. J. Bone and Joint Surg., **35-A**: 489–494, April 1953.

that the only cause for non-union in the case of an intracapsular fracture is to be found in our inability to maintain coaptation and immobilization of the fragments during the time required for bony union to take place".

When I started the practice of orthopaedics, the Whitman abduction plaster treatment was well established. This procedure represented the first real effort to demonstrate concretely the fundamental truth so well enunciated by Senn. In fact, his dictum has spurred the continuous effort to improve the methods of fixation throughout the past thirty years. The successful results achieved in treatment have been directly proportional to the accuracy of the reduction obtained and the ability to maintain adequate fixation of the fragments.

In addressing this distinguished assembly, it would be superfluous to present a chronological and comprehensive review of the attainments in the treatment of transcervical and subcapital fractures of the femur. You are all familiar with the trials and tribulations which have plagued and perplexed us, but this period has in no way been one of continuous failures and disappointments. You all are well acquainted with what has been accomplished by certain outstanding and far-reaching developments which have provided us with a greater understanding of the many problems. It is impossible for any of us to think of the treatment of a fractured hip without being reminded of our beloved Smith-Petersen and his epoch-making contribution of the three-flanged or trifin nail for intramedullary fixation. Later, the introduction by Johannson of the cannulated nail made it possible to employ internal fixation without direct visualization. Pins and nails and screws in various forms have been introduced by numerous authors and have been extensively used in attempts to procure better internal fixation. These technical devices have not introduced any new therapeutic principles, but represent modifications in the method of accomplishing the basic purpose of internal fixation.

A contribution of the most significant value was made by Phemister, who gave us a much clearer understanding of the reparative processes of creeping substitution and revascularization. The outstanding studies by Pauwels and by Linton on the mechanical factors in femoral fractures contributed to our increased realization of the importance of shearing stress in preventing immobilization and union. There has been real progress in our knowledge of bone-grafting, especially concerning the advantages of cancellous bone, which permits rapid revascularization, as has been so well brought out by Abbott and others.

Progress in the treatment of fractures at the hip joint has also been greatly augmented and enhanced by fundamental contributions in other special fields. With modern roentgenographic techniques, it is possible to procure excellent lateral projections to ascertain whether or not the reduction is satisfactory; and the progress of the nailing procedure can be followed by roentgenographic visualization in the operating room. Improved methods of anaesthesia and replacement of blood, amino acids, and electrolytes have been of great aid in minimizing surgical shock. The use of antibiotics has also lessened the possibility of postoperative infection.

The progress so far recorded in the treatment of intracapsular femoral fractures is, therefore, a composite achievement to which many authors have contributed with ingenuity, vigor, and competence. As a result of all these efforts, the trend has been one of continuous gain; it seems to me that this gain should be exploited further, not ruthlessly discarded.

The "unsolved" fracture has been one of my major interests for many years, and the challenge it offered has lured me on to try to improve my own results in the treatment of this condition. Although the results were never quite so good as I was hoping for, I have seen gradual improvement which has constantly stimulated me to continued effort to increase my understanding of the problem and to improve my surgical technique, in pursuance of basic principles. As Browning said: "Ah, but a man's reach should exceed his grasp, or what's a heaven for?" In this gradual and continuous struggle I have learned

much, and it seems only logical that this cumulative experience might be applied on a much wider scale to improve the results of treatment of transcervical femoral fractures.

Many of you may favor the use of different procedures and you may disagree with some of my conclusions, but I ask your indulgence toward this formulation of some of the ideas which have evolved as the result of my own prolonged study and clinical experimentation.

First of all, I want to emphasize that the goal of treatment today is the same as that emphasized by Senn fifty years ago,— namely, anatomical reduction and complete immobilization of the fracture. It is important, I believe, that the primary attention should be focused on this goal, which represents the basic principle of treatment, rather than on the particular technique or mechanical device which is being used to achieve it. The significant fact is not that this or that nail or screw or osteotomy be used, but that each or any of these be regarded as a means available for use, according to the indications in the particular case, to bring about the desired purpose of reduction and complete immobilization. The mechanical support used and the surgical technique selected should be those which appear most likely to achieve the desired result in view of the site and angulation of the fracture, and, in later stages, the degree of the fibrous process indicating a beginning non-union.

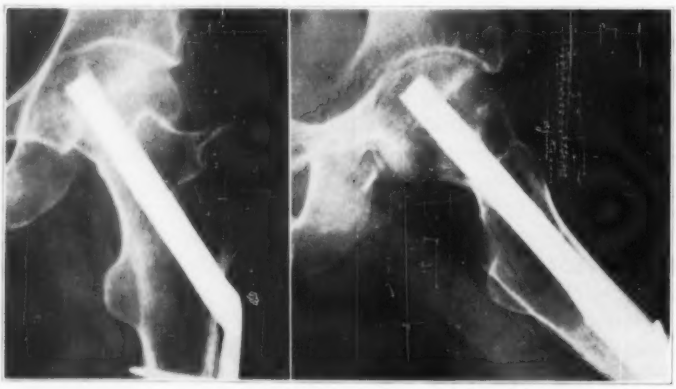

FIG. 1

Placing of Jewett nail low in the neck, with shaft fixation.

We all know the end result we desire to achieve, but often its accomplishment is not easy and some technical difficulty or inaccuracy may intrude during the procedure which may influence the result unfavorably. I still wonder at the complacency of many surgeons who say that it takes them just fifteen minutes or so "to slip in a pin". Whether it is the best procedure that could be done under the circumstances apparently causes them no concern.

As Michelangelo said, "The genius among you is the one that has the infinite capacity for taking pains". Satisfactory results in the treatment of transcervical fractures of the femur are dependent on meticulous planning, proper equipment, and perfect execution of good engineering principles, with infinite attention to each and every detail. It was such minute attention to details in the planning and organization of the British expedition led by Major Hunt that resulted in the final victory in scaling Mount Everest.

As the result of my observations, I believe that future improvement in the treatment of the "unsolved" fracture will come by more meticulous care in the early stages. It is essential, in the handling of the acute fracture, to procure an anatomical reduction, or even a slightly overcorrected position, as advocated by McElvenny. If a satisfactory reduction cannot be procured by closed manipulation, then open reduction should be done. To procure absolute and complete immobilization is a problem more difficult to solve. Whatever device is used, it should procure the best possible mechanical fixation and still be within the realm of practical application.

The method most generally used for internal fixation of fractures of the femur is the

Smith-Petersen cannulated trifin nail. Despite the number of excellent results with its use, I am sure that it does not fulfill in all cases one of the primary requisites of complete immobilization. If any engineer or cabinet maker had a similar problem, he would use an angle support or brace and would not depend on a nail alone. For several years, I have been using the Jewett-type trifin nail, which gives additional fixation to the shaft, and so, of the devices now available, comes nearest, in my opinion, to fulfilling the necessary requirements. My experience indicates that this type of nail, properly placed in low position in the neck so that it practically rests on the calcar femorale, together with the added shaft fixation, apparently increases the stability and thus increases the likelihood of bone healing at the fracture site (Fig. 1). The nail should extend about two thirds of the way across the head fragment in an attempt to provide maximal support and still give sufficient clearance to avoid protrusion of the nail if impaction or absorption of bone should take place. When the fracture is well reduced and adequately fixed, however, absorption of bone at the fracture line during healing is minimal.

Even with the advantages of shaft fixation, it is sometimes extremely difficult to obtain complete immobilization in the case of some subcapital fractures, in which the small proximal fragment is balanced on the top of the nail and the resulting shifting at the fracture site may give rise to bone absorption and a tendency toward proximal protrusion of the nail. In attempts to minimize this possibility, special nails have been used, such as those designed by Dr. Carl Badgley and by Dr. Willis Pugh; they have the advantage of shaft fixation, but are so constructed that the blade can back out if any absorption should occur at the fracture site, thus assuring continued impaction and maintenance of position. I have not had the opportunity to use these modified nails myself, but, in principle, they would seem to have definite virtue.

As we all know, in the normal healing of a fracture, a continuous hematoma is formed between the two fragments. This hematoma first changes to granulation tissue, then to undifferentiated connective tissue. At this stage, if immobilization is complete, the undifferentiated connective tissue changes to bone and healing proceeds to completion. In instances in which the head fragment has been completely separated from its blood supply by the fracture, healing has to be accomplished by creeping substitution and revascularization, as demonstrated by Phemister.

On the other hand, if fixation of the fracture is unsatisfactory and there is instability at the fracture site, the undifferentiated connective tissue resulting from the original hematoma changes to fibrous tissue, which acts as a barrier to vascular pathways across the fracture line, thus preventing the possibility of normal healing or of creeping substitution, with subsequent revascularization of the head fragment. In fractures of the hip in which the fibrotic changes appear, the inevitable result would be non-union or avascular necrosis of the head, or both.

Once there is evidence of delayed union, the condition invariably progresses from bad to worse. In order to detect delayed healing or early non-union, the patients are subjected to extremely close supervision, with several roentgenographic examinations during the first year. If any change in position or absorption of bone is detected, this situation is dealt with promptly. The scar tissue which has formed a barrier to vascular supply can be completely removed and replaced with a graft of cancellous bone. This results in the formation of another hematoma and, with the cancellous graft across the fracture line, not only is stability increased, but there is a stimulus and a pathway for revascularization of the head. The patient is thus given a second chance for a normally functioning hip.

In 1939, I reported a method of using a cancellous-bone graft for the treatment of non-union of femoral-neck fractures (Fig. 2). The drawing on the left shows a medium-angled subcapital fracture which was nailed according to principles we believe to be correct,—that is, a nail placed low in the neck and centrally in the head with adequate shaft fixation. For the purpose of the discussion, we shall assume that the follow-up

roentgenograms, two, three, four or six months after operation, showed signs of early non-union. If that should happen, we would then, without delay, do a grafting procedure, with cancellous bone extending from the neck well into the head, as illustrated on the right. A typical result obtained with such a graft in a case of early non-union is demonstrated in Figures 3-A and 3-B. The first of these (Fig. 3-A) displays the definite non-union evident six months after the original operation; the second shows the result two years later, following replacement of the Jewett nail in better position and grafting with cancellous bone.

As a rule, according to my own observations, this grafting leads to restoration of blood supply to the head segment. The promptness with which this return of circulation is accomplished, as soon as possible after the presence of a fibrous-tissue barrier is recognized, is extremely important in preventing avascular necrosis of the head. Once avascular changes have become well established, the process apparently is irreversible by grafting.

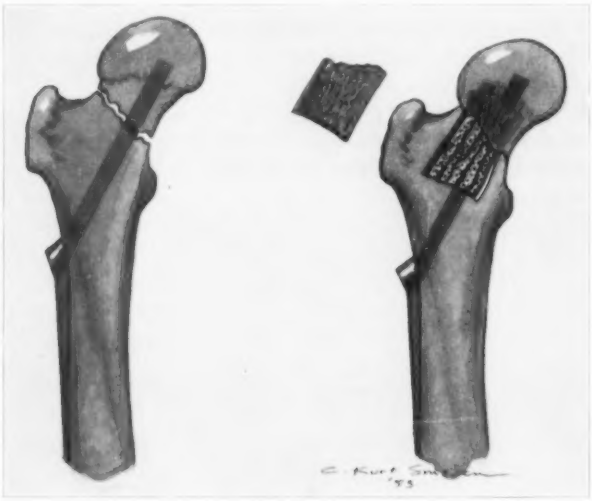

FIG. 2

Diagram showing placement of cancellous-bone graft in cases of early non-union.

I wish to digress here for a moment to point out that there are certain cases in which a cancellous-bone graft, even when it is inserted so early that one would anticipate a satisfactory result, does not prevent the progression of aseptic necrosis. These cases would appear to be somewhat analogous to the avascular changes sometimes seen in the head of the femur after dislocations, when there is no fracture to complicate the picture. In these instances, there is evidently some factor other than the interruption of blood supply by the fracture which interferes with the nutrition of the head fragment. This probably results from fibrotic and necrotic changes as a result of a thrombosis which makes revascularization difficult or impossible. Nevertheless, I believe that this represents the exception rather than the rule. It is my impression that, in the great majority of cases, avascularity of the head results from a fracture which is not impacting and from the fibrous-tissue barrier which develops because of this instability.

I cannot overemphasize the advantage of the use of cancellous bone rather than cortical bone for replacement in such grafting procedures. The traditional method of grafting the neck of the femur with a piece of cortical bone or fibula driven across the fracture line, as evidenced by the results in the hands of many different surgeons, does not promote rapid healing of the fracture and in many instances does not improve the situation. Sometimes it may even make matters worse because, in driving the cortical-bone graft across the fracture line, the head fragment may be disimpacted or angulated, and this contributes to unsatisfactory healing and continuing non-union. To carry out this traditional type of grafting in cases of non-union or avascular necrosis is like bringing a garden hose to a six-alarm fire!

If the beginning non-union is promptly recognized and dealt with, a cancellous-bone graft is usually sufficient to correct the situation; but in the more advanced cases of estab-

lished non-union, in which there has been absorption at the neck of the femur, the head of the bone assumes a varus position, the angle of the fracture line tends toward the vertical, and the fracture is not impacting. In the presence of such a problem, an osteotomy is indicated to eliminate the existing shearing stress, which, as Pauwels and Linton have

FIG. 3-A

Non-union of transcervical femoral fracture six months after initial treatment with a Jewett nail.

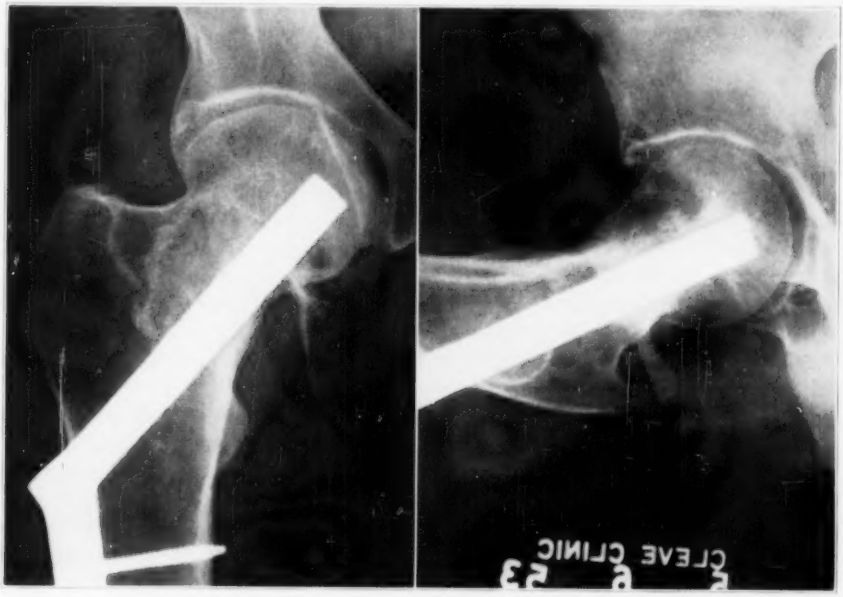

FIG. 3-B

Same patient two years after the changing of the position of the nail and insertion of a cancellous-bone graft.

FIG. 4

Diagram of high-angled fracture with established non-union, treated by rotation osteotomy of 45 degrees and a cancellous-bone graft.

demonstrated, is a major factor in preventing union in fractures of the neck of the femur. Several types of osteotomy for ununited fractures of the femoral neck have been advocated by McMurray, Leadbetter, Reich, Blount, King, and others. These procedures have been extensively used; and, although they have aided in stabilizing the hip in many instances, too often union of the fracture was not obtained, the hip was still painful, and the functional results were unsatisfactory.

Since I had obtained such encouraging results from the use of cancellous-bone grafts in correcting the early cases of non-union, when there was no problem of mechanical error, it seemed logical that the combination of a precisely controlled osteotomy to correct the angulation of the fracture line, combined with a grafting procedure with cancellous bone to promote revascularization, might salvage many of these cases in which we had previously thought we had no choice but a reconstruction or prosthetic procedure. Figure 4 shows a diagram of a high-angled fracture with established non-union which could not be nailed or grafted into a stable position. Since impaction is necessary for a rapid and complete take of the graft, the rotation osteotomy, which I first reported in 1947, is utilized to provide the necessary stability. The degree of rotation, which can be controlled according to the technique described, is such that the head of the femur is brought into its normal relationship within the acetabulum and the fracture angle is changed to assure impaction of the fragments. In the majority of cases, a rotation of 45 degrees has proved effective. This overcomes the shortening of the extremity and returns the abductor muscles of the hip to normal length and function. The drawing on the right (Fig. 4) shows that the fracture has been grafted with cancellous bone, extending from the neck well into the head segment.

Figures 5-A and 5-B show the sequence of events in a patient with advanced non-union of a fracture at the neck of the femur, which had been present for a year at the time the roentgenograms shown in Figure 5-A were made. Figure 5-B shows the anteroposterior and lateral roentgenograms made five years after rotation osteotomy and cancellous-bone grafting. Another typical result obtained by the combined procedure of rotation osteotomy and cancellous-bone graft is demonstrated in Figure 6-A, which shows the attempts that had been made elsewhere to nail the fracture and to graft it with cortical bone. When I saw the patient, two years after the fracture had occurred, there was non-union of the high-angled fracture, with a varus position of the head. Figure 6-B shows the result, four

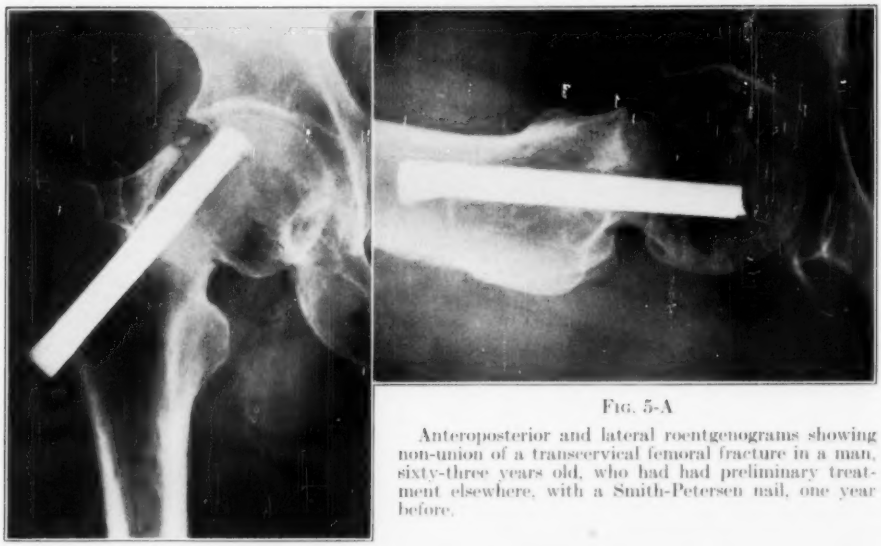

FIG. 5-A

Anteroposterior and lateral roentgenograms showing non-union of a transcervical femoral fracture in a man, sixty-three years old, who had had preliminary treatment elsewhere, with a Smith-Petersen nail, one year before.

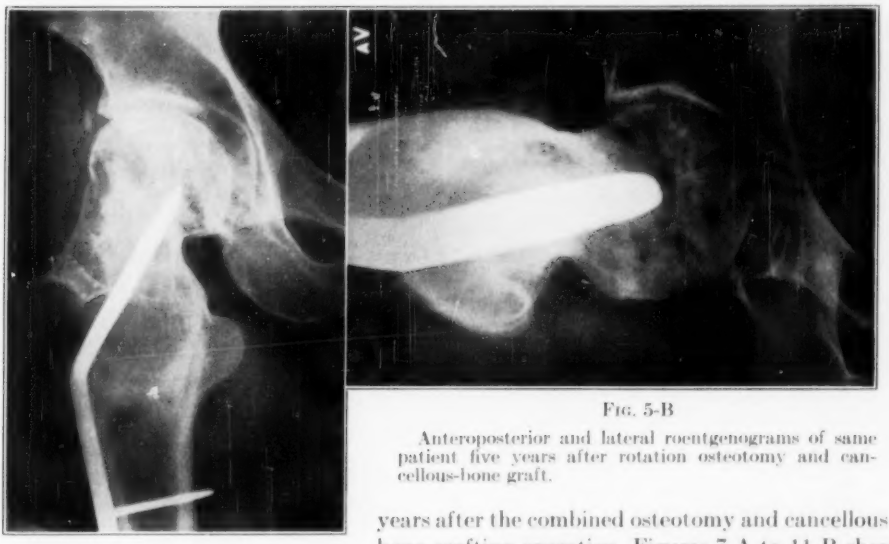

FIG. 5-B

Anteroposterior and lateral roentgenograms of same patient five years after rotation osteotomy and cancellous-bone graft.

years after the combined osteotomy and cancellous-bone-grafting operation. Figures 7-A to 11-B show the results of cancellous-bone grafting and the combined procedure with osteotomy in patients with non-union who had been treated initially by various methods.

I wish to emphasize that every one of these patients would have been a candidate for a hip prosthesis today if he had come under the care of some of our orthopaedic confreres. The results shown in the roentgenograms speak for themselves. These patients had preliminary care with various methods, including the Whitman plaster, the Thomas splint, the lag screw, the Smith-Petersen nail, and the Jewett nail, and, regardless of the method used, non-union occurred. After being treated with cancellous-bone grafting or the combined procedure of osteotomy and grafting, all these patients obtained almost normally functioning hips with no limitation of motion, no pain, no shortening of the leg, and no limp; and they do not need crutches or canes. Furthermore, these satisfactory results

have been maintained for years. If such results can be procured in cases like these, they should be accomplished more often. There is no doubt in my mind that they could be,

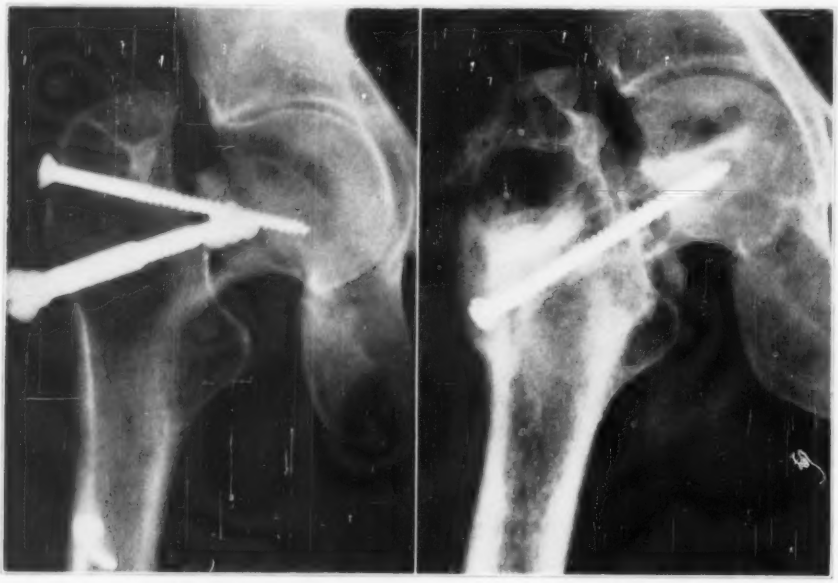

FIG. 6-A FIG. 6-B

Fig. 6-A: A man, aged forty-six, fractured his hip on May 6, 1947. Blind pinning was attempted and later a lag screw was inserted. In August 1947, a bone graft and screw were inserted, but absorption occurred, with resultant non-union.

Fig. 6-B: Roentgenogram shows condition of hip joint when first seen, two years after the fracture.

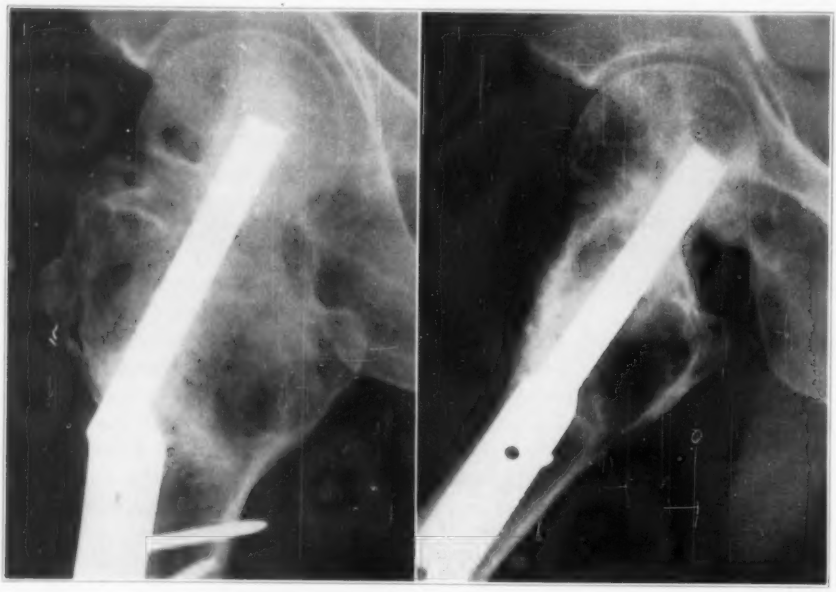

FIG. 6-C

Result four years after rotation osteotomy and cancellous-bone graft.

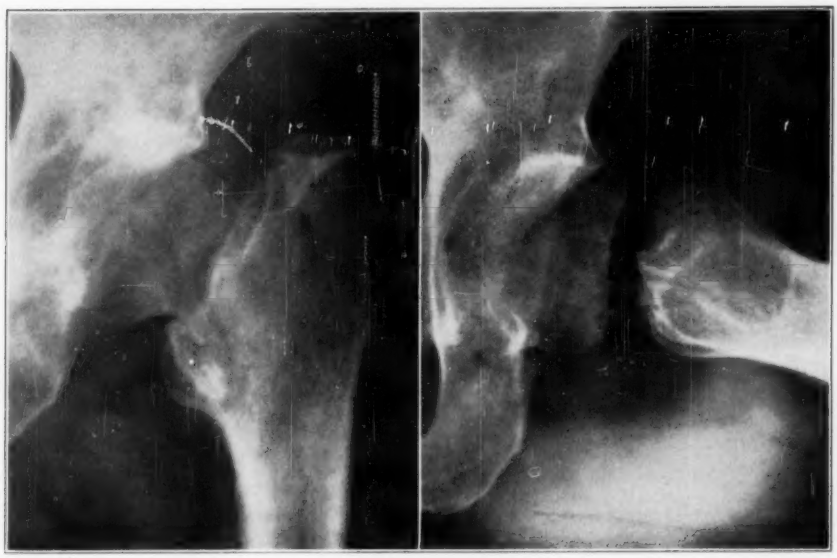

FIG. 7-A

Roentgenograms showing non-union of transcervical femoral fracture six months after application of a Whitman spica in a man, sixty-nine years old.

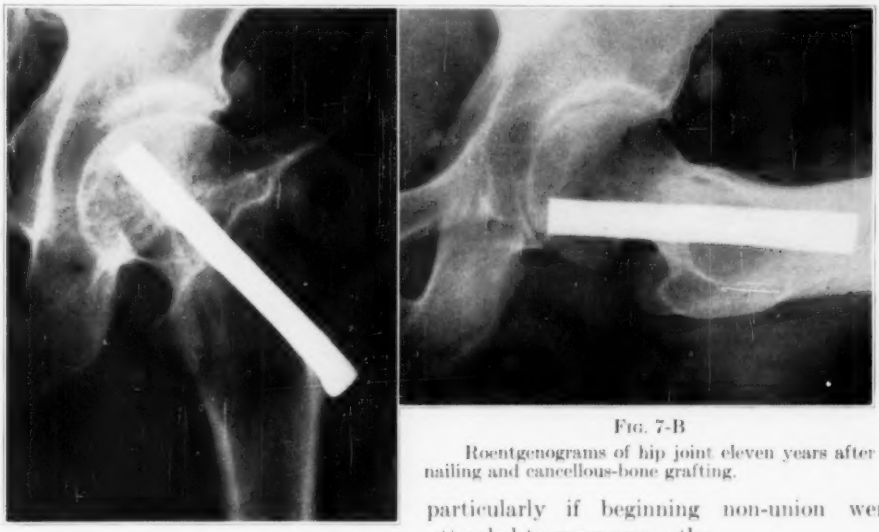

FIG. 7-B

Roentgenograms of hip joint eleven years after nailing and cancellous-bone grafting.

particularly if beginning non-union were attended to more promptly.

Hence, I reiterate that I must protest the attitude of defeatism inherent in the present vogue for prostheses. As you have seen, even if there is evidence of slipping or of early non-union, there is still a possibility of procuring union and a normally functioning hip. It is my firm conviction that a prosthetic substitution should not be adopted until every effort has been made to preserve bone stock.

Unfortunately, because of the inadequate methods of internal fixation generally used at present, about one of every four fractures at the femoral neck goes on to non-union. This percentage varies somewhat, depending upon the accuracy and skill of the primary reduction and fixation. As I have tried to bring out, a good portion of these non-unions

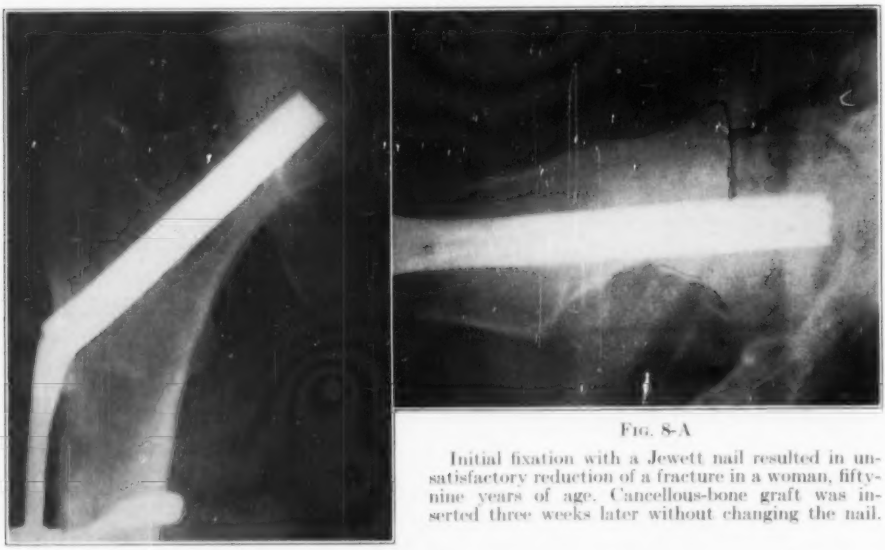

FIG. 8-A

Initial fixation with a Jewett nail resulted in unsatisfactory reduction of a fracture in a woman, fifty-nine years of age. Cancellous-bone graft was inserted three weeks later without changing the nail.

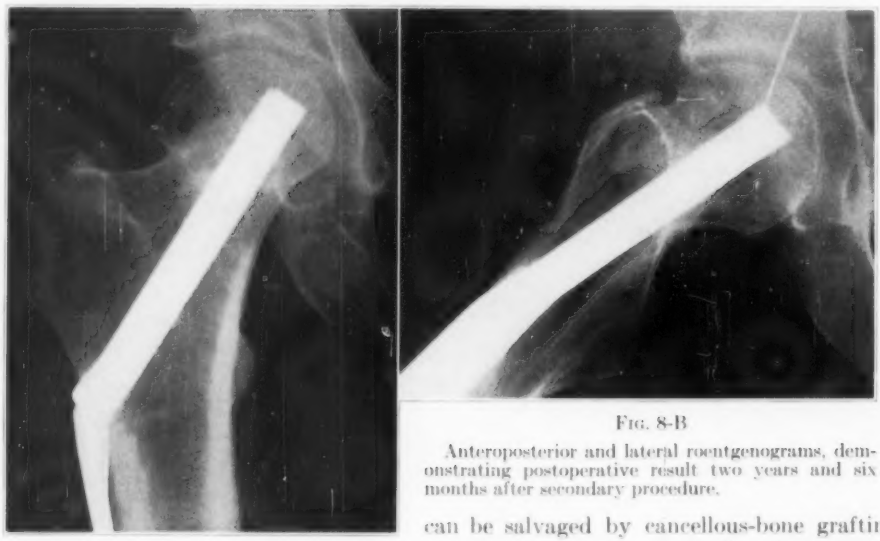

FIG. 8-B

Anteroposterior and lateral roentgenograms, demonstrating postoperative result two years and six months after secondary procedure.

can be salvaged by cancellous-bone grafting or osteotomy and a cancellous-bone graft. If the surgeon realizes his opportunity, these procedures give the patient a second chance.

There is a peculiar trait in the human race, and it is especially pronounced in surgeons,—that we tend to ignore our failures. It is only with the greatest reluctance that some surgeons can admit to the patient that the progress studies on the fractured hip show evidence of a beginning non-union. Invariably, when any evidence of fibrosis appears at the fracture site, the situation cannot get any better; it can only go from bad to worse, and then to worst. This unfavorable progression is inevitable; but, as a rule, instead of doing something about it, the surgeon instructs the patient to report for another roentgenogram in ten or twelve weeks. That roentgenogram, of course, shows evidence that the condition is worse than it was before; yet the policy of procrastination continues, and all the while, the opportunity to procure a union of the fracture and revascularization of

the head segment by grafting or osteotomy and grafting gradually diminishes. As George Horace Lorimer has said: "Putting off an easy thing makes it hard, and putting off a hard one makes it impossible". This attitude of procrastination and neglect during the early progress of the fractured hip should be considered a sin of omission on the part of the surgeon. When further treatment is delayed until avascular necrosis has become established in the femoral head, revascularization becomes improbable and a reconstruction operation, an arthrodesis, or a prosthetic appliance becomes necessary. I cannot overemphasize the urgency of early recognition of a beginning non-union and the prompt adoption of suitable treatment.

The recognition of what can be accomplished in the given case is one of gradual and progressive education and experience. Since the results of early cancellous-bone grafting have proved so successful in my experience, one might question why all cases of subcapital femoral fractures should not be subjected to grafting with cancellous bone at the time of the primary procedure of reduction and fixation. Dr. O'Donoghue of Sioux City, Mr. Patrick of Glasgow, and Dr. Bado of Montevideo have carried out primary cortical or fibular grafting in acute fractures and have reported somewhat improved results. Even these results might have been better if cancellous bone had been used. As I see it, however, in view of the fact that satisfactory results are obtained in approximately 75 per cent. of these fractures with nailing alone, it would not be justifiable to perform the more complicated operation of bone-grafting as a routine procedure in all cases. Instead, I advocate that these patients be subjected to very careful observation, with repeated roentgeno-

FIG. 9-A

Anteroposterior roentgenogram, showing non-union of a transcervical fracture of the femur in a woman, sixty-nine years old, one year and three months after initial treatment with traction and a Thomas splint.

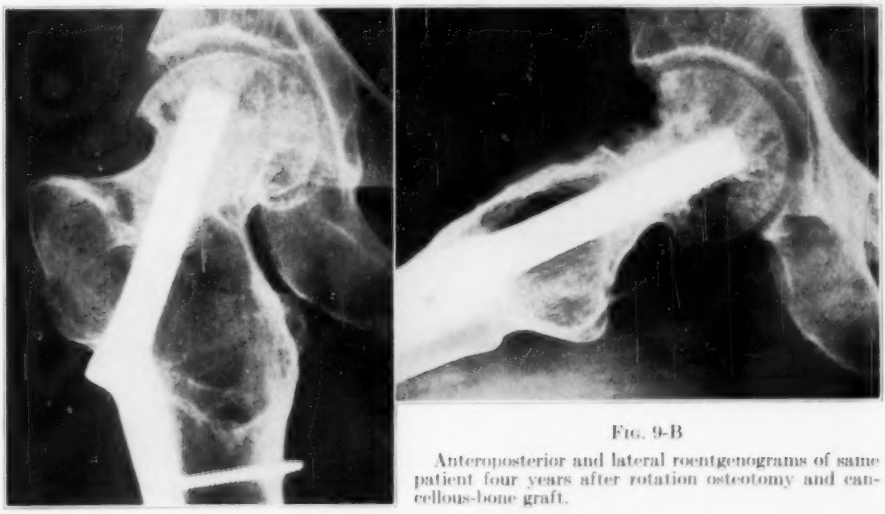

FIG. 9-B

Anteroposterior and lateral roentgenograms of same patient four years after rotation osteotomy and cancellous-bone graft.

graphic studies, and that grafting be employed promptly in all cases in which there is delayed healing or any evidence of beginning non-union. In my own work, I have not used cancellous-bone grafting as a routine measure in acute fractures, but I have performed this procedure in all cases in which trouble seemed imminent, with results that have been exceedingly satisfactory.

During the last few years, many of the patients referred to me for possible further treatment have had non-union and avascular necrosis which had already developed to

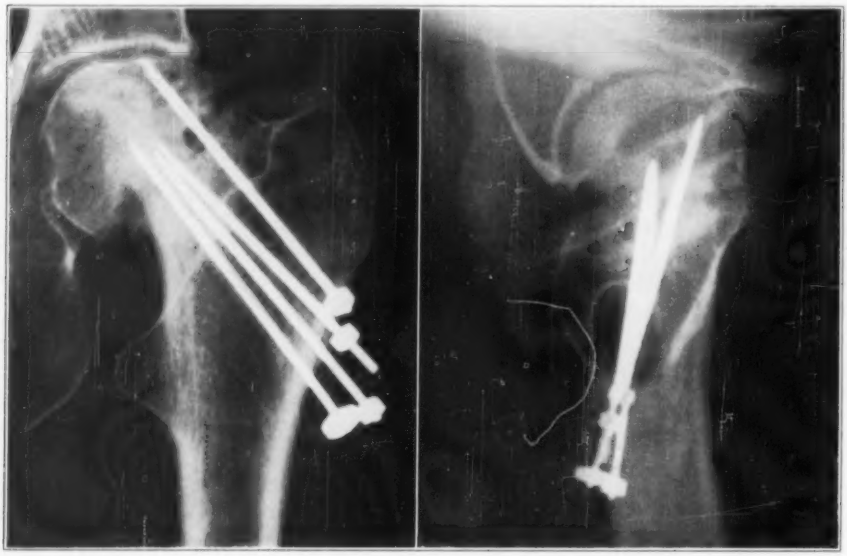

FIG. 10-A

Anteroposterior and lateral roentgenograms showing non-union one year after insertion of multiple pins for transcervical fracture of the femur in a woman, aged fifty-seven.

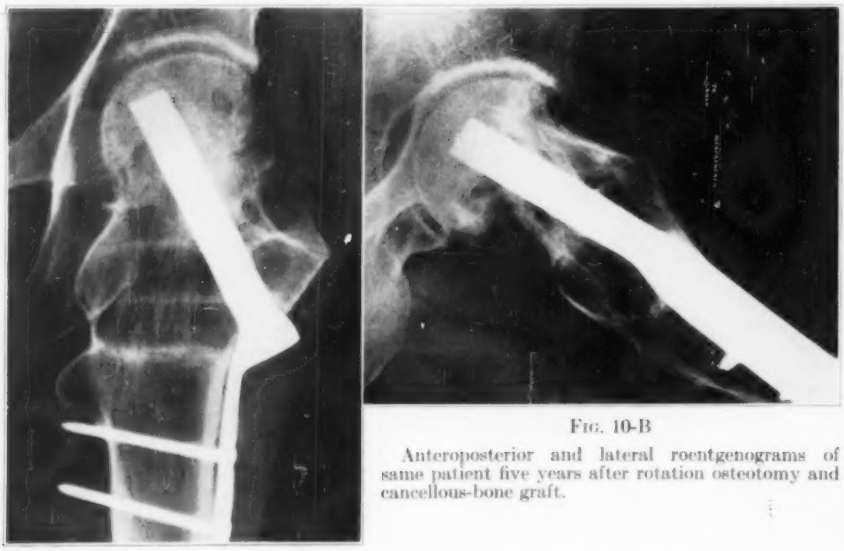

FIG. 10-B

Anteroposterior and lateral roentgenograms of same patient five years after rotation osteotomy and cancellous-bone graft.

such an advanced stage that grafting procedures were out of the question. When the aseptic changes have become definitely established, a reversal of these changes is apparently impossible. However, in reviewing the series of roentgenograms which these patients brought with them, there was evidence that, months or years earlier, they would have been suitable candidates for the grafting procedure or grafting with osteotomy, with a reasonable hope of complete rehabilitation.

There would be no point in attempting to present any statistics on my own series, since I have not been able to follow a sufficient number of patients from the time of the fracture to the completion of the treatment. For this reason, I cannot make any predic-

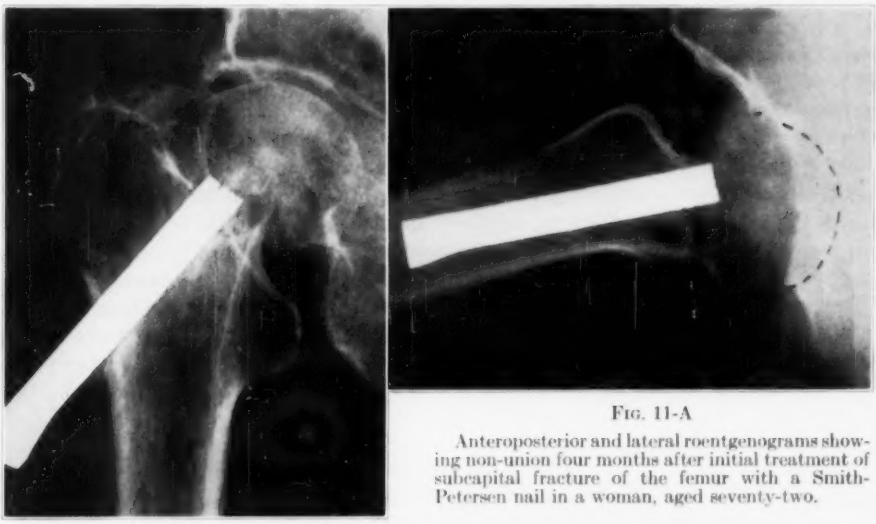

FIG. 11-A

Anteroposterior and lateral roentgenograms showing non-union four months after initial treatment of subcapital fracture of the femur with a Smith-Petersen nail in a woman, aged seventy-two.

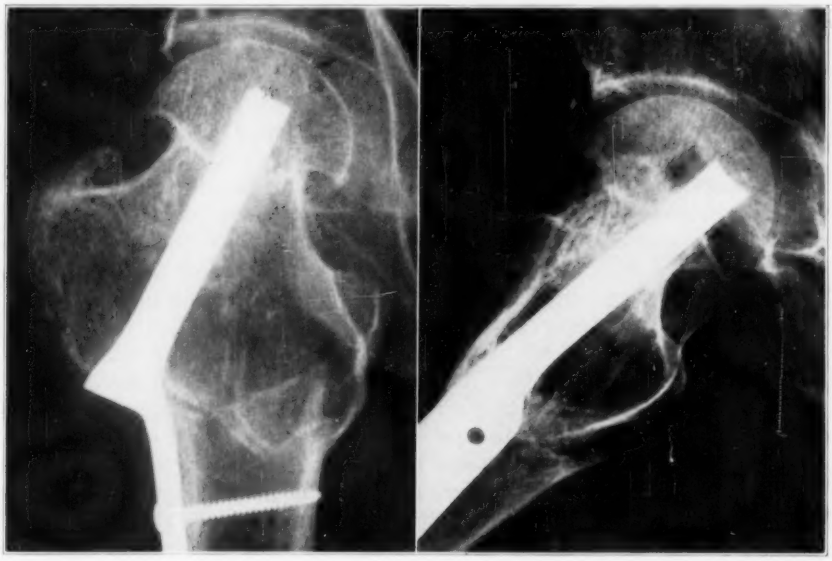

FIG. 11-B

Anteroposterior and lateral roentgenograms three years and eight months after rotation osteotomy and cancellous-bone grafting.

tions, on the basis of my own experience, as to what proportion of the 25 per cent. of cases of transcervical fractures of the femur which now go on to non-union or avascular necrosis or both can be reclaimed. The results would depend on the choice of cases for secondary grafting or combined grafting and osteotomy procedures, and the skill with which the technical methods are applied. What I wish to emphasize is that with the adoption of the principles here outlined, better results can be procured than are being obtained at present. I have been very much more interested in the application of the best surgical principles which would solve the problems encountered in individual clinical cases than in working out any statistical evaluations. Statistics tell us how many cases were unsuccessful, but they do not tell us *why* they went wrong.

Percentage figures on a series of cases which any one individual or institution can present in a problem of this sort actually have little weight. A proper statistical evaluation can be based only on a much larger number. The figures that we now have on transcervical fractures of the femur represent aggregates of results reported with the use of many different methods and by many different operators, each working individually. There are no figures which represent the results of a concerted and coordinated attack on the problem, following a well conceived plan decided upon by a group cooperating in a program designed to explore all facets of the problem. Until some such study is made, in which all that we have learned by adding our individual efforts through the years is applied systematically and consistently over a long enough period to see just what can be accomplished, we should not be discouraged by the problem of the "unsolved" fracture.

As I have tried to demonstrate, much progress has been made to date, even though each of us has been working individually in his own little sphere. With what has already been done as a basis, I believe that some real team work, such as went into the successful ascent to the peak of Mount Everest, might solve this problem of fractures of the neck of the femur.

The members of the medical profession have always displayed their altruism by a consistent policy of sharing knowledge with each other for the benefit of their patients. At a meeting such as this, we cannot help but be impressed with the undeviating honesty, superior intelligence, highly developed skill, and towering achievements which have characterized this sharing of information and experience. However much we have accomplished through such individual exchange of ideas in the past, I believe that we could achieve even more if, in expressing the same unselfish motives, we would revise our methods of cooperation to conform to the complexities and the needs of the twentieth century.

In this we might well take a cue from "Big Business" in designing an agency somewhat analogous to that which the General Motors Company, for example, has in its Technical Center, where all problems of research are carefully planned with attention to and expert advice on each phase of the problem, so that data collected at many points can be compared and evaluated. I believe that this Association has an opportunity and a duty to form an active committee, preferably working with the Committee for the Advancement of Orthopaedic Surgery of the Academy, whose function would be to plan and to organize a concerted attack on the "unsolved" fracture and on other problems in orthopaedics. What has not yet been done by simple addition of our individual efforts might well be accomplished by multiplication of our efforts and integration through a central agency in our organization. In an endeavor of this kind, the interest of a common enterprise would be placed above individual interest, and difference of opinion or conflicting judgments would not arise to interfere with the solution of the problem under consideration, because the program of investigation to which all would contribute would be devised by a competent team who would consider all facets of the problem in organizing a feasible project. The focal centers of such investigative activity would be in educational institutions, but the program should be so organized that valuable data might also be contributed by orthopaedists from their individual practices.

I am certain that some such integrated program of action by all the members of our group would solve the "unsolved" fracture. From what we now know, it seems obvious that final victory must come through prevention of irreversible damage which precludes the restitution of normal function. This means that an integrated research program would be attempting to devise further improvements in internal fixation, would be making basic studies on the factors which cause avascular necrosis and on the process of osseous regeneration, and would be collecting data on clinical trials with new technical methods, to mention only a few of the more obvious phases, and would keep the entire group informed of the progress being registered.

Until some such cooperative attack is made on the problem of transcervical fractures of the femur, we should not consider it an "unsolved" fracture. If these intracapsular fractures do not unite properly, it is because we have used unsatisfactory methods, or because effective methods have not been applied at the right time. Until there is general, widespread use of the best techniques now available, with proper attention to correct timing, and until we have seen the results of integrated studies and coordinated efforts, we have no basis for judging what can be accomplished. For this reason, I repeat once more, I protest the attitude of defeatism. Let's not "just give it up". Instead, let's see what can be done!

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THE DIAGNOSIS AND TREATMENT OF GIANT-CELL TUMORS OF BONE *

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Errors of diagnosis or classification of giant-cell tumors of bone are frequent and the controversy about the so-called variants is still rampant. Jaffe, Portis, and Lichtenstein, individually and in collaboration, have decried the careless inaccuracy or indifference of histopathologists who diagnose any lesion in which they find a scattering of multinuclear cells nesting in a connective-tissue stroma as "giant-cell tumor". In so doing, these giant-cell enthusiasts ignore the fact that non-osteogenic or non-ossifying fibroma, unicameral bone cyst, localized osteitis fibrosa, and other so-called variants have very little in common with the genuine giant-cell tumor. The differences are clinical, roentgenographic, anatomical, histological, and biochemical.

The genuine giant-cell tumor is not so benign as it was once thought to be. Recurrence after treatment is not uncommon and malignant manifestations do occur. The non-ossifying fibroma (sometimes most unwisely labeled "cortical giant-cell tumor"), localized osteitis fibrosa, solitary bone cyst, and other so-called variants do not recur when excised, and they do not metastasize. Not only does the true giant-cell tumor present certain clinical, anatomical, roentgenographic and biochemical characteristics which set it apart from all other lesions; but usually it can be correctly identified and differentiated from all others by the critical and alert histopathologist on the basis of its cytological details.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1953.

The mere presence of true giant cells, even in large numbers, is not sufficient evidence to justify a diagnosis of giant-cell tumor of bone. There are a number of other characteristics typical of a true giant-cell tumor, some of which will be present in any lesion correctly diagnosed as giant-cell tumor. Among the findings in typical giant-cell tumors of bone are the following:

1. The patients are nearly all young adults. (The average age in a large series was found to be 28.4 years [14].)

2. The majority of giant-cell tumors originate in the end of long bones in the portion which during the growth years was the epiphysis.

3. Pain, often present at night as well as during activity, is common. By contrast, there is almost never pain associated with a solitary bone cyst, fibrous dysplasia, non-ossifying fibroma, and other conditions which the pathologist sometimes erroneously diagnoses as giant-cell tumor [6, 15].

4. Tumefaction is present early and is usually palpable and tender.

5. The expanded cortex of the bone is often paper-thin and may crackle when palpated.

6. Roentgenograms show a circumscribed osteolytic but expansile tumor, and not uncommonly the thin expanded cortex of the bone is perforated. The larger giant-cell tumors may appear multilocular, and the roentgenograms have been described as having a "soap-bubble" appearance.

7. Roentgenograms rarely reveal any periosteal reaction such as is present in many other types of bone lesion.

8. The stromal cells in a giant-cell tumor of bone show evidence of greater activity in growth and multiplication and in variety of morphology than do the stromal cells of most other lesions which commonly contain giant cells.

9. Stromal cells as well as giant cells in a true giant-cell tumor contain acid phosphatase and contain no alkaline phosphatase.[2]

10. Giant cells in a bone cyst, in fibrous dysplasia, or in non-ossifying fibroma and other similar lesions are fewer in number. They may contain acid phosphatase, but *the stromal cells of lesions which are not true giant-cell tumors contain only alkaline phosphatase and never acid phosphatase.*[2]

Each of the ten characteristics listed may be present in a single large giant-cell tumor. Unless several of these typical findings are present in any given tumor of bone, we are not dealing with a true giant-cell tumor.

The following two cases are presented to show the folly of trying to destroy large giant-cell tumors by x-ray therapy. The degree of success of x-ray irradiation therapy of a giant-cell tumor is determined for the most part by the size of the tumor. Some small giant-cell tumors may be completely destroyed by x-ray therapy, with resultant healing of the lesion. There have been reports of development of sarcoma in tissues irradiated in the treatment of giant-cell tumors.[1, 4, 14] The risk may be small, but cannot be ignored. The large giant-cell tumors cannot be completely destroyed by x-ray therapy alone without great injury to all other tissues in the field of irradiation. Excessive irradiation has resulted in extensive damage to skin, muscles, and other soft tissues surrounding the tumors, with only partial destruction of the giant-cell tumors. Usually, portions of the tumor continue to grow, so that the size increases in spite of the fact that some of the tumor may have been necrosed by the roentgen therapy.

Case 1. M. W., fifty-one years old, was admitted to Wesley Memorial Hospital on September 15, 1951, because of a pathological fracture of the condyle of the left femur, marked enlargement of the condyles of the left femur and of the knee joint, deformity characterized by angulation, and severe pain which was present at night as well as when the extremity was moved. This patient had first become aware of the swelling and pain in the region of the left knee about two years before. At that time the roentgenograms showed a destructive, expansile lesion in the lateral condyle of the left femur (Fig. 1-A). Giant-cell tumor was diagnosed and she was given roentgen therapy. Biopsy was not done. Irradiation was repeated at inter-

FIG. 1-A

Case 1, M. W. Roentgenograms made December 20, 1949, shortly after x-ray therapy had been started, showing destructive lesion in the lateral condyle of the left femur.

FIG. 1-B

Roentgenograms made nineteen and twenty-one months later showed marked increase in size of the tumor, with destruction of most of both condyles and some of the adjacent metaphysis, as well as a pathological fracture and deformity. This continued expansion had occurred in spite of intensive and repeated irradiation.

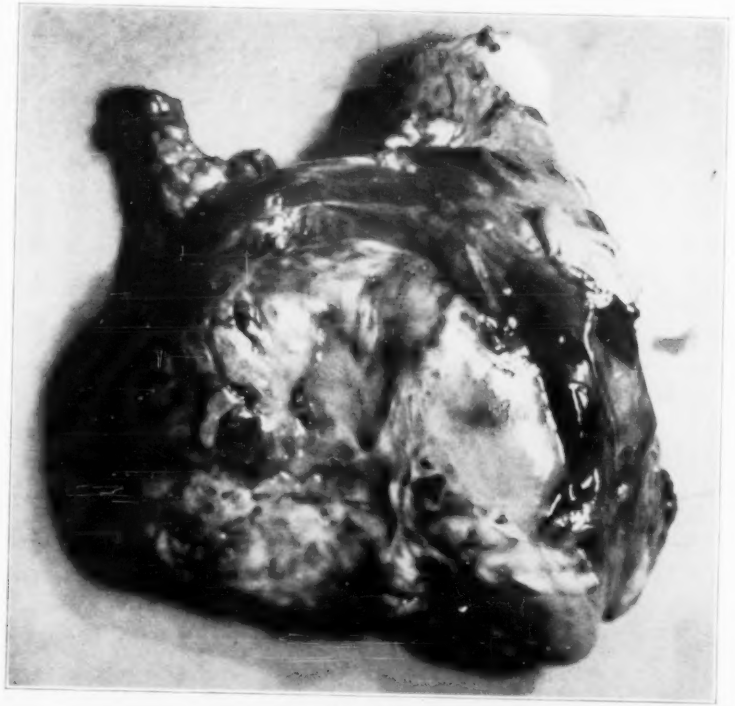

FIG. 1-C

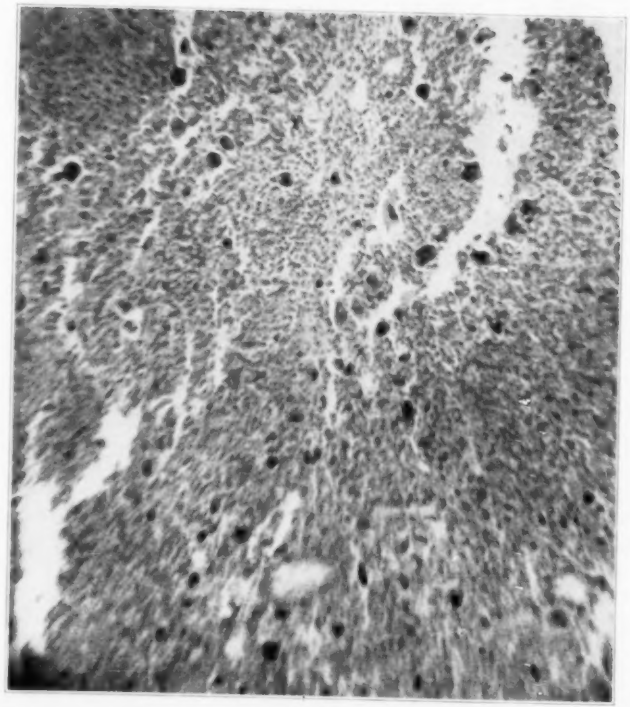

FIG. 1-D

Fig. 1-C: Gross specimen of the resected tumor mass, including both condyles and a portion of the shaft of the femur. After the fracture the tumor had invaded the knee joint.

Fig. 1-D: Photomicrograph (× 50) showing typical stroma containing a number of giant cells. Although the skin, subcutaneous tissue, and muscles in the area were relatively avascular, the tumor was richly supplied with blood. It was obvious that irradiation in this instance had produced more injury to the normal than to the tumor tissue.

vals over a period of the two years from the time of onset until the spontaneous fracture occurred shortly before she was examined by the author. In spite of extensive irradiation, the tumor had continued to enlarge.

The skin over the lower third of the thigh, including the knee joint itself, was thick, brawny, and discolored as a result of the irradiation. Roentgenograms which were made following her admission to Wesley Memorial Hospital showed an extensive tumor mass and collapse of the shell-like enlarged lateral condyle of the femur (Fig. 1-B).

Mid-thigh amputation was obviously the easiest method of treatment. Few fifty-year-old women patients subjected to above-the-knee amputations are able to use any type of prosthesis, however. This patient had a normal foot and good muscles in the calf of the leg, and we decided to save the limb if at all possible.

The distal fourth of the left femur, together with all of the tumor tissue, was excised (Figs. 1-C and 1-D). The proximal end of the tibia was likewise removed. Massive autogenous tibial-bone grafts and grafts from the bone bank were used to bridge the defect between the tibia and the remaining segment of the femur. A clover-leaf Kuntscher nail was inserted in the tibia at the level of the lower and middle thirds and driven upward until it engaged the femur, bridging the defect and maintaining alignment. The bone grafts previously referred to were embedded in the tibia and their proximal ends were placed in contact with the femur. They were tied bundle fashion around the intramedullary nail.

The muscles which were exposed during the operation were brown in color and much damaged from the extensive irradiation. As a result, there was a breakdown of the wound and subsequent healing was slow. The operation was performed September 18, 1951, and healing of the soft tissue was complete April 11, 1952. On July 11, 1952, the bone grafts appeared to have united. The half-cylinder splint was discarded. This patient had been walking for nearly two months with full weight-bearing while wearing a posterior

FIG. 1-E

Anteroposterior and lateral roentgenograms, made on April 18, 1952, showing alignment maintained by the intramedullary nail and union of the bone grafts to the tibia. In the lateral view there is evidence of beginning union of the proximal ends of the bone grafts to the femur, seven months after resection.

plaster splint. She continued to walk with full weight-bearing for about four weeks after the plaster splint had been discontinued, and then without any known strain or injury she became aware that the limb could not take her weight. On August 11, 1952, approximately eleven months from the time of operation, a roentgenogram revealed the fact that the intramedullary pin had broken in the space between the femur and the tibia.

FIG. 2-A

Case 2, C. P. Roentgenogram made in 1940 shows pelvis of a white male, twenty-four years old. A diagnosis of giant-cell tumor of the left ilium was made and treatment by irradiation therapy was started. At this time, the acetabulum was still intact. (Courtesy of St. James Hospital, Chicago Heights, Illinois.)

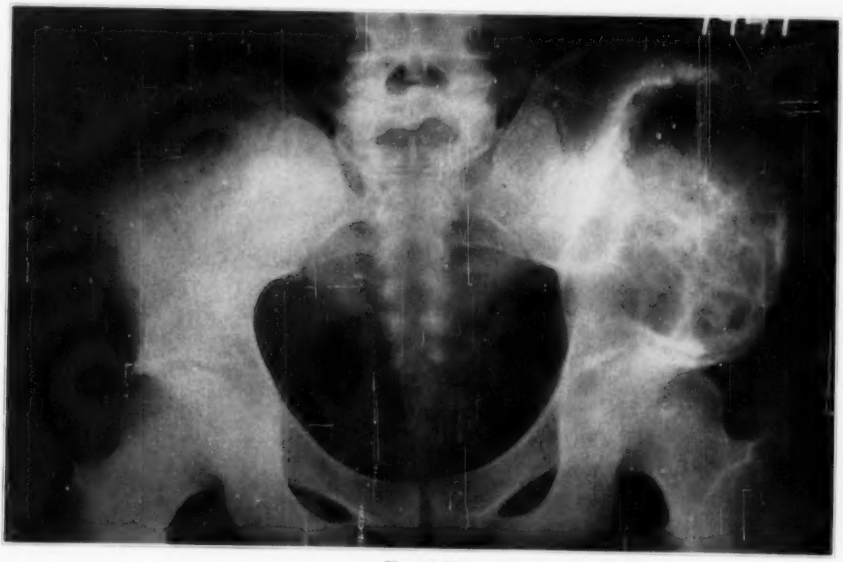

FIG. 2-B

A roentgenogram made in 1941 showed that, in spite of irradiation, the tumor mass had become larger and a pathological fracture into the hip joint, with resultant pain and inability to bear full weight, had resulted. (Courtesy of St. James Hospital, Chicago Heights, Illinois.)

The grafts were still firmly united to the tibia but had broken away from their attachment to the femur.

On August 20, 1952, the broken clover-leaf nail was removed and replaced with two solid Rush nails which were inserted through the opening in the tibia at the levels of the lower and middle thirds. Fresh bone chips and small bone grafts were packed about the distal end of the femur and the bone grafts, which

FIG. 2-C

By 1944, necrosis of the skin and of the underlying soft tissue had resulted in a draining sinus and the upper portion of the hip joint was completely destroyed. (Courtesy of St. James Hospital, Chicago Heights, Illinois.)

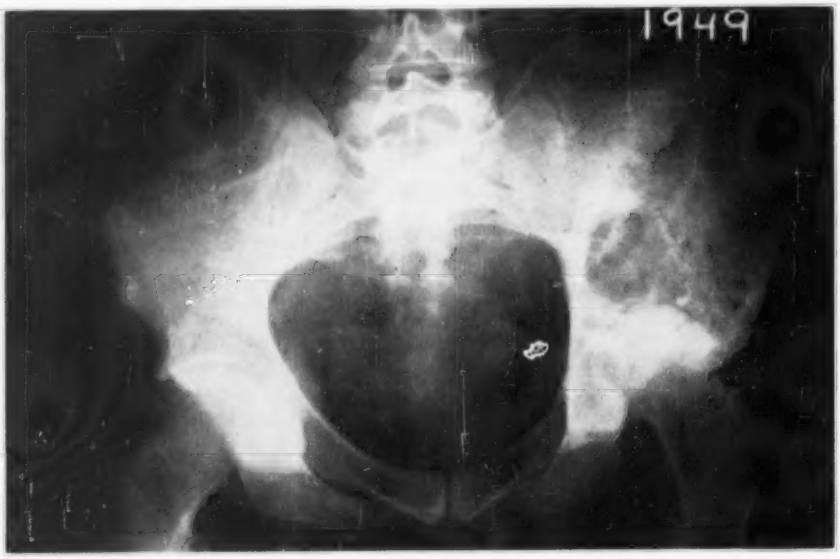

FIG. 2-D

A roentgenogram made in 1949 showed further destruction of bone and some increase in ossification within the tumor tissue. At this time the patient was in constant pain and had lost twenty pounds in weight.

were still united by fibrous tissue. Examination on December 10, 1952, showed satisfactory healing. Roentgenograms showed evidence of union of the bone grafts to the femur as well as to the tibia. The patient was able to bear weight on the foot on the involved side without discomfort. The intramedullary Rush pins were holding securely. There was shortening of nearly four centimeters. This patient is walking with crutches, but is bearing almost full weight on the foot on the involved side. We are optimistic about recovery with good stability and freedom from pain.

This patient could have been cured more surely and with less disability by adequate surgery when the diagnosis was first made.

Case 2. C. P., thirty-six years old. This patient was first examined at the age of thirty-three by my associate, William J. Schnute, on May 31, 1949. Ten years before he had complained of pain and lameness in his left hip. A biopsy at that time had revealed the presence of giant-cell tumor. Roentgenograms showed extensive destruction of most of the left ilium. Roentgen therapy was recommended and administered in amounts not known to us. (It is difficult to understand why anyone would have preferred to use roentgen therapy for a tumor which was the size of a large cocoanut and located in an area accessible for surgical removal. Such a tumor could not be destroyed by irradiation without injury to other tissues in that region.) As a result of intensive roentgen therapy the skin and soft tissue overlying the tumor were severely damaged. A sinus developed and continued to drain year after year. The patient lost twenty pounds in weight. When he was examined by Dr. Schnute in May 1949, he was an invalid cripple. He could walk with crutches, but with difficulty. The irradiation burn was extensive. There was a large crusting, scar-like area overlying his left ilium (Fig. 2-E).

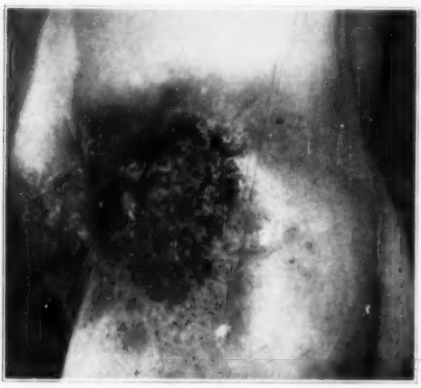

Fig. 2-E

Fig. 2-F

Fig. 2-E: Photograph made on June 2, 1949, showed the extensive x-ray burn and necrosis of the skin.
Fig. 2-F: Roentgenogram made March 2, 1950, after excision of most of the ilium, thorough curettement of bone just above the level of the acetabulum, and a Brittain type of fusion carried out by Dr. W. J. Schnute. The patient is now rehabilitated and there has been no evidence of recurrence.

On June 27, 1949, Schnute carried out an operation which removed most of the ilium and all of the tumor tissue. The operation confirmed the x-ray appearance of complete destruction of the left hip joint. The acetabulum had been essentially normal in 1940 and, if the tumor had been removed at that time, the hip joint could have been preserved. The various operations carried out by Schnute were as follows:

On June 5, 1949, the sinus tract was excised together with exuberant granulation tissue and much of the scarred skin overlying it.

On June 27, 1949, partial iliectomy was done.

On October 31, 1949, the granulating area which had filled in at the site of removal of this tumor was covered with small skin grafts.

On December 12, 1949, a Brittain arthrodesis of the hip was performed.

On December 17, 1952, the patient weighed more than 200 pounds, walked without crutches, and stated that he could be active with full weight-bearing without pain for hours at a time. He played golf during the summer and fall months.

SUMMARY

Giant-cell tumor of bone should be differentiated from all other lesions which also contain multinuclear giant cells, including solitary bone cyst, non-osteogenic fibroma, aneurysmal bone cyst, chondromyxoid fibroma of bone, benign chondroblastoma, and the "brown tumors" sometimes found in hyperparathyroidism. The giant-cell tumor of bone is clinically, anatomically, and cytologically a distinctive neoplasm. The pathologist who depends entirely upon the microscopic examination and ignores the clinical history and roentgenographic examination will make many errors of diagnosis.

Irradiation as a primary or total plan of treatment of giant-cell tumors of bone is neither certain of cure nor free from danger. The larger giant-cell tumors cannot be destroyed by irradiation without severe damage to adjacent tissues. Most giant-cell tumors may be adequately and safely treated by surgery, followed in some instances by irradiation therapy.[5, 8, 12, 13]

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CHONDROMYXOID FIBROMA OF BONE

Report of Two Cases*

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This newcomer to the field of benign tumors of bone was described by Jaffe and Lichtenstein in 1948. We have found only two additional reports [1, 3] in the subsequent literature, each of which described a single case. Because this neoplasm appears to have a distinctive histological appearance, pursues a characteristically benign course, and may be confused with malignant tumors, especially chondrosarcoma, we are presenting two additional examples.

REPORT OF CASES

Case 1. A white woman, thirty-six years old, registered at the Mayo Clinic on July 31, 1942. The pertinent complaint was pain in the right knee. On physical examination tenderness over the medial condyle of the affected tibia was noted. Roentgenographic examination revealed a region of decreased density measuring 2 by 1.5 centimeters in the anterior portion of the medial condyle of the right tibia (Fig. 1-A). The tumor was removed by curettage on October 28, 1942, and the edges of the resulting inverted-cone-shaped cavity were treated by means of electric cautery. A letter from the patient dated December 5, 1951, indicated that the right knee was causing no trouble; accompanying roentgenograms revealed no activity of the lesion.

The gross specimen measured 2 by 2 by 1.5 centimeters and had well circumscribed borders. It was firm and somewhat brittle. It was partially translucent but was more gray than is hyaline cartilage. Microscopically, most of the tumor consisted of small stellate cells lying in a myxoid, slightly basophilic, intercellular matrix (Fig. 1-B, upper view) which contained scattered collagenous fibers. The periphery of the tumor was distinct (Fig. 1-B, lower view) in contrast to the appearance of this zone in chondromatous or myxomatous tumors of bone. At the slightly lobulated periphery, the tumor cells were chiefly round or oval and were more numerous than in the central portions. Multinucleated cells were not observed and the nuclei of the cells were uniformly small and benign-appearing throughout. In small portions, especially near the periphery, the intercellular material had assumed a homogeneous and more eosinophilic appearance, and here the nuclei lay in lacunar spaces resembling those of cartilage.

Case 2.† A white man, twenty-six years old, had noted recurrent episodes of pain over the right fifth rib for three years. These had begun after an injury. Roentgenographic examination revealed a slightly expanding, rarefactive lesion of the right fifth rib (Fig. 2-A). The patient has been well since the tumor was removed in April 1951.

This tumor, which again had a maximal diameter of approximately two centimeters, had well defined borders (Fig. 2-B, upper view) similar to those of the tumor in the first case. A considerable portion of the slightly lobulated neoplasm consisted of myxoma-like cells, but several islands exhibited a distinctly chondromatous appearance (Fig. 2-B, lower view). Although most of the neoplastic cells had rather small nuclei, an occasional binucleate cell and occasional cells with prominent nuclei were found in some parts of the tumor, especially near the more cellular periphery.

COMMENT

The lucid description of chondromyxoid fibroma of bone presented by Jaffe and Lichtenstein made it easy to recognize the tumors in our two cases as examples of this

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1953.

† We are indebted to Dr. Louis G. Nezworski of Ironwood, Michigan, who has given us permission to present this case.

FIG. 1–A

Fig. 1–A: Case 1. Note the rarefaction in the upper part of the right tibia.

Fig. 1–B: The upper view (×200, hematoxylin and eosin stain) shows the myxoma-like pattern, large regions of which were present in the tumors in both cases. The lower view (×180, hematoxylin and eosin stain) shows the distinct peripheral zone with chondroid regions.

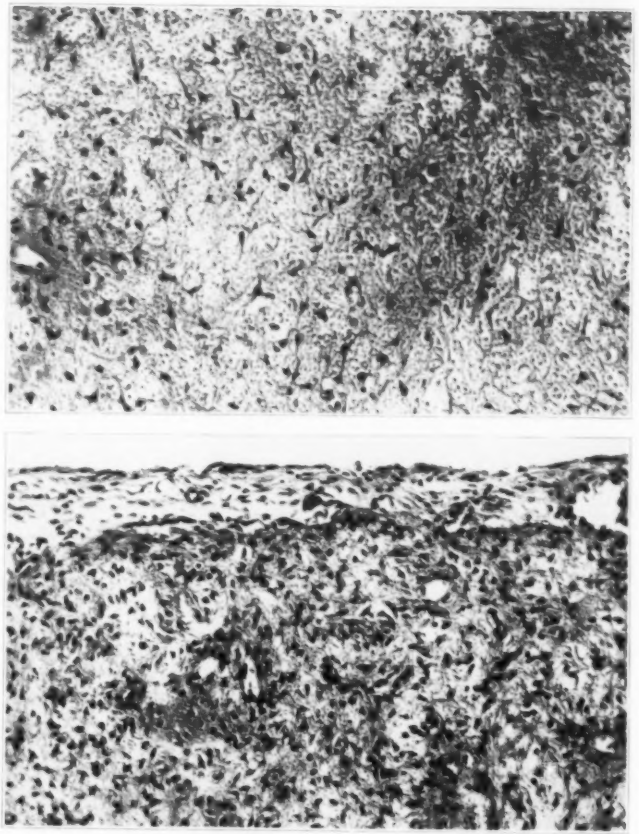

FIG. 1–B

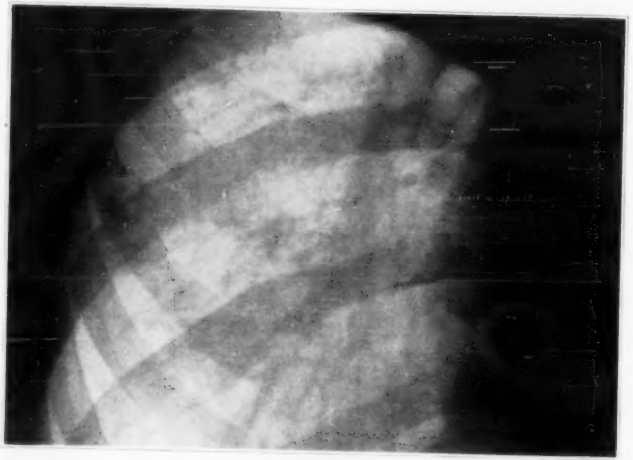

FIG. 2–A

Fig. 2–A: Case 2. Showing a rarefactive, expanding lesion in the right fifth rib.

Fig. 2–B: The upper view (×130, hematoxylin and eosin stain) shows the slightly irregular cellular border of the tumor. The upper layer consists of condensed connective tissue surrounding the tumor proper. The lower view (×280, hematoxylin and eosin stain) shows the chondroid region, with irregularly shaped cells lying in lacunae.

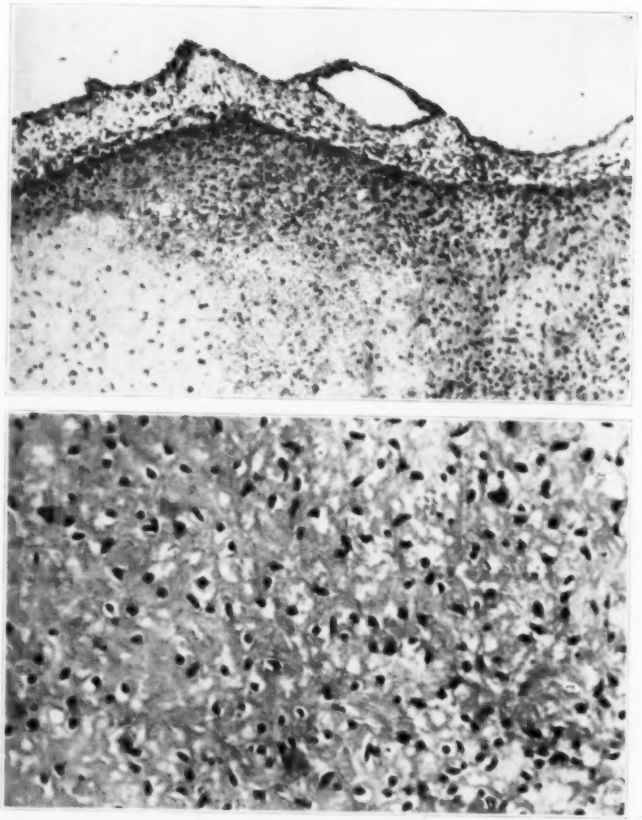

FIG. 2–B

entity. The chondroid areas and the pseudolobulation with condensation of cells at the well demarcated border of the neoplasm serve to differentiate clearly these tumors from so-called myxoma of bone. The myxoid features, the pattern of growth, and the peripheral demarcation without extension of the tumor between the trabeculae of the surrounding bone serve to differentiate it from chondroma or chondrosarcoma. The benign clinical course of this tumor, as emphasized in the original series and by follow-up studies in our Case 1, makes the differentiation from chondrosarcoma important. The patient in our second case is well; however, only one and a half years have elapsed since operation. It is unlikely that chondromyxoid fibroma would be confused histologically with tumors of bone other than those mentioned.

The two cases described in this paper bring to twelve the total number of cases of these tumors we have been able to discover. All but two of the neoplasms were in a bone of the lower extremity. Five affected the tibia, two the femur, two a metatarsal, and one the calcaneus. The tumor in our Case 2 is the second reported example in a rib. The lesions tend to be round or ovoid and have measured as much as approximately eight by five centimeters. In long bones, the tumors involve the metaphysis.

The patients' ages have ranged from thirteen to fifty-six years; eight of the twelve were less than thirty years of age.

Three clinical features of importance are associated with these tumors: (1) Pain has been a complaint in all the recorded cases; (2) the majority of patients have noted a palpable mass in the region of the tumor; and (3) the mass may be tender to palpation and tenderness may be present in the absence of swelling.

Roentgenographic examination reveals a circumscribed zone of decreased density which may be confused with such lesions as fibrous dysplasia, bone cyst, and enchondroma. The rarefied region is sometimes trabeculated. Jaffe and Lichtenstein attributed this appearance to the inner boundary of the tumor, which may be distinctly grooved and even somewhat sclerotic. If the cortex has been breached, the bony contour may bulge and a thin layer of periosteal new bone may or may not cover the neoplasm.

The treatment of choice appears to be curettage. This operation has proved curative in all the cases in which adequate follow-up studies have been made. If the resultant cavity is large, it may be necessary to fill it with chips of bone or a bone graft.

The gross and microscopic features of chondromyxoid fibroma of bone have been thoroughly discussed by Jaffe and Lichtenstein. These authors are in fundamental agreement with the pathological description given in our two cases and further comment seems unwarranted.

ADDENDUM

Since this paper was prepared, six additional typical examples of this lesion have been uncovered in a comprehensive study of bone tumors in the files of the Mayo Clinic. Two of these affected the upper portion of the tibia, two the ilium, one the lower portion of the femur, and one a metatarsal. The clinical and pathological features in these six cases are similar to those previously described.

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RETICULUM-CELL SARCOMA OF BONE*

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Reticulum-cell sarcoma of bone is one of the entities which has been rescued from the Ewing's tumor "waste basket". Histopathological recognition of this relative newcomer assumes more than didactic importance because of its better prognosis as contrasted with most primary malignant bone tumors. Parker and Jackson established the identity of this neoplasm in 1939.

The incidence of reticulum-cell sarcoma, apparently primary in bone, is not well established. Relatively few articles have appeared on the subject and these have been predominantly reports of single cases. Coley, Higinbotham, and Groesbeck published data on thirty-seven of their cases encountered at Memorial Hospital. Valls, Muscolo, and Schajowicz reported on ten cases seen in their practice during an eight-year period. Our forty-nine reticulum-cell sarcomata were found among approximately 2,000 specimens of primary bone tumor preserved at the Mayo Clinic. The specimens were secured from 1905 to 1952 inclusive. During the same period slightly more than eighty Ewing's tumors were encountered. Our forty-nine reticulum-cell sarcomata of bone include the thirty-two which form the material of the report by McCormack, Ivins, Dahlin, and Johnson.

PATHOLOGICAL FEATURES

The gross appearance of reticulum-cell sarcoma of bone does not differ remarkably from that of some of the other lytic malignant processes of bone; for example, highly anaplastic fibrosarcomata, metastatic deposits, or Ewing's tumors. In the region of involvement, variable, usually moderate, destruction of bone occurs. Subperiosteal reactive new-bone formation, similar to that observed in chronic osteomyelitic processes or even in Ewing's tumors, may be seen. This appears to be attributable to elevation of the periosteum by the growing tumor. The extra-osseous extensions of the neoplasm may be soft and friable as is, for example, reticulum-cell sarcoma which arises in lymph nodes. Often, however, considerable collagen within the neoplasm makes it rather firm. The central portion may be necrotic and the advancing edges of the tumor tend to be indistinct.

Microscopically, the diagnostic cell of this neoplasm is the reticulum cell, which differs in no recognizable manner from that in reticulum-cell sarcoma of soft-tissue origin. As is illustrated in Figure 1, this cell has an indented or lobulated nucleus. Its chromatin is rather coarse and one or more nucleoli usually are present. The cytoplasm is ordinarily indistinct. These cells vary somewhat in size and nuclear hyperchromatism, but the basic morphological characteristics are otherwise always the same. There is a prominent tendency for the cells to be disposed in alveolar arrangement. Reticulin or coarser collagenous deposits usually separate the cells into small clusters or rows. The connective tissue ordinarily is readily evident in preparations stained with hematoxylin and eosin (Figs. 2 and 3). Special stains for reticulin have not aided us in diagnosis in troublesome cases. As has been stressed by Parker and Jackson, many of these tumors contain fairly large numbers of lymphocytes. This feature is important to remember since it creates the danger, at biopsy, of mistaking a small specimen from one of these tumors for inflammatory tissue. This mixture of lymphocytes, lymphoblasts, and reticulum cells is often

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1953.

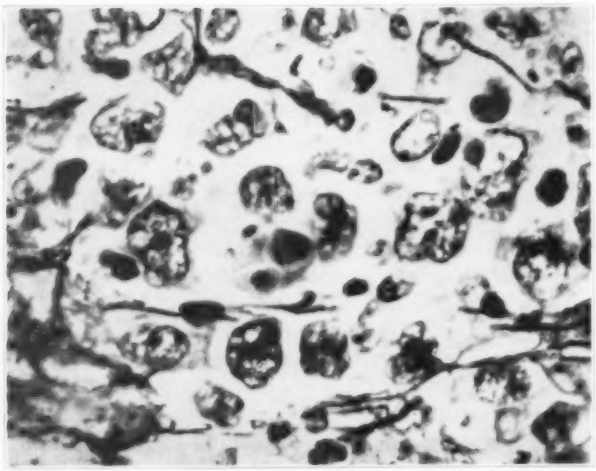

Fig. 1

Fig. 1: Reticulum cells with their characteristically lobulated or indented nuclei and rather prominent nucleoli. (×800, Gomori reticulin stain.)

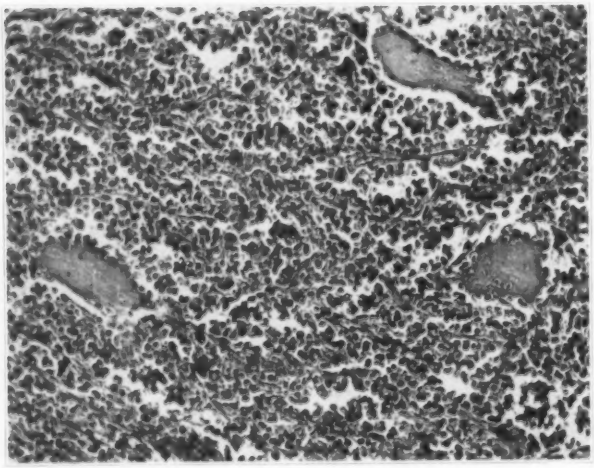

Fig. 2

Fig. 2: Reticulum-cell sarcoma. The alveolar pattern produced by the reticulin and the collagen deposits in the tumor is shown. (×125, hematoxylin and eosin stain.)

seen in comparable malignant growths of lymph nodes.

Metastatic deposits of reticulum-cell sarcoma frequently are observed to be partially or completely replacing regional lymph nodes. Occasionally distant deposits are observed; and in some cases, omitted from this study, it could not be determined with any assurance whether the lesion of bone was primary or whether it was part of a systemic process. In the cases used in this study the clinical histories, physical examinations, and roentgenograms indicated that the sarcomata most likely began in bone, that is, the patients presented the problems of a primary bone tumor.

Considerations of differential diagnosis, from the histopathologist's standpoint, include Ewing's tumor especially, small-cell osteogenic sarcoma, multiple myeloma, and the benign reticulo-endothelial disorders such as eosinophilic granuloma. The nuclei of the cells of Ewing's tumor, compared with those of reticulum-cell sarcoma, are smaller; they are round or slightly oval, uniform in size, and do not possess clumped chromatin. The cells occur in large clusters among widely separated strands of stroma (Fig. 4). There is, we must admit, a group of bone tumors, vastly outnumbered by Ewing's tumor and reticulum-cell sarcoma, which appears to lie histologically and cytologically between these two groups. For the time being, we have no name for these neoplasms and we have omitted them from both groups. The rather rare osteogenic sarcoma, made up of small cells, does not have indented or lobulated nuclei and ordinarily osteoid tissue is produced by these cells in at least a portion of the tumor. The indented nuclei of the cells found in cases of benign reticulo-endotheliosis contain almost no chromatin or nucleoli and ordinarily offer no problem in identification. Occasionally an anaplastic plasma-cell myeloma may exhibit cells very much like reticulum cells and, rarely, we have observed tissue which we would consider characteristic of reticulum-cell

sarcoma in a tumor which elsewhere had distinct features of plasma-cell myeloma. In the vast majority of cases of myeloma, of course, the immature plasma cells make identification obvious.

CLINICAL FEATURES

As has been indicated, forty-nine cases form the basis of this report; included are thirty-two cases previously reported [2]. The cases have been divided into two groups for purposes of clinical study. Group I includes thirty-nine cases in which the initial examination revealed a solitary lesion of the skeleton and in which the diagnosis of reticulum-cell sarcoma of bone was made from tissue removed from this lesion. In addition—although this was not made a criterion for selection in this group—definitive treatment in the patients in this group was given after biopsy at the Clinic. Cases of this group fulfill the requirements for consideration as unequivocal cases of primary reticulum-cell sarcoma of bone. Group II is made up of ten cases which, although more than one lesion was present at the time of the initial examination, we consider to be cases of primary reticulum-cell sarcoma of bone[2].

Table I lists the incidence with which this tumor was encountered at the Mayo Clinic during different periods. On the basis of these figures, it seems reasonable to expect that we shall encounter reticulum-cell sarcomata of bone with increasing frequency. Table II gives the distribution of patients by age and by sex. It is to be noted that about half (that is, twenty-five) of the patients were seen before the age of forty years, the incidence being fairly evenly distributed among the adult age groups. In Table III is summarized the duration of symptoms. In the group with solitary lesions, the duration recorded is that prior to the first examination; in the group with multiple lesions, that since

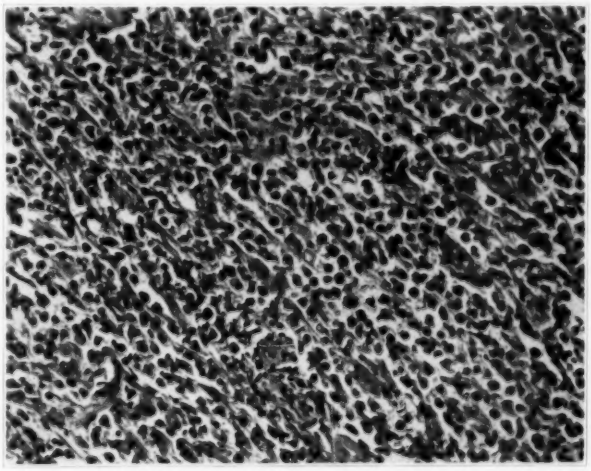

FIG. 3

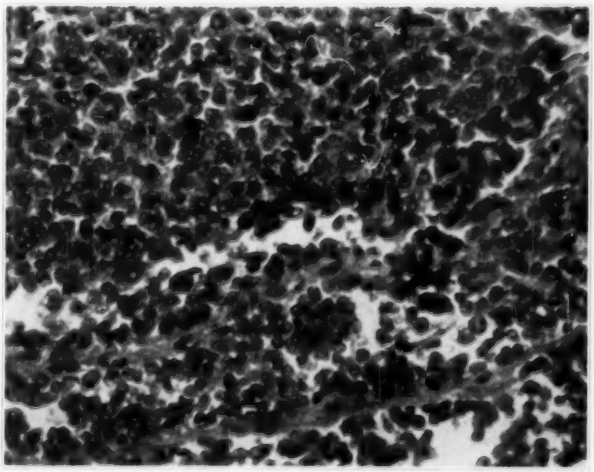

FIG. 4

Fig. 3: Reticulum-cell sarcoma. Note the strandlike rows of the neoplastic cells separated by fine stromal bands. (×200, hematoxylin and eosin stain.)

Fig. 4: Ewing's tumor. The smaller, regular, round or slightly oval cells and the paucity of stroma are characteristic of this tumor. (× 285, hematoxylin and eosin stain.)

TABLE I

DISTRIBUTION BY YEAR

Year	Solitary Lesions	Multiple Lesions
Before 1920	5	2
1920–1929	7	2
1930–1939	9	3
1940–1949	11	2
1950	3	0
1951	2	1
1952	2	0
Total	39	10

appearance of the first lesion. It is to be noted that, regardless of whether there was one lesion or several, symptoms had been present for a year or less in more than half the patients and the symptoms of relatively few of the patients had been present for longer than two years. The mean duration of symptoms in the two groups was the same.

Figure 5 shows the anatomical situation of the thirty-nine solitary lesions. About half (twenty) were in the pelvis or lower extremity; about a fourth (nine) were in the shoulder girdle or upper extremity, and the remaining fourth (ten) were in the head, including the jaws, or the spinal column. In the ten cases in which lesions were multiple, only two or three sites were involved in some, but in many cases involvement of both bone and soft tissues was widespread.

Detailed study of the entire group revealed nothing new or significant as regards symptomatology. The most constant presenting symptom was pain; all but three patients complained of pain, but few described it as more than mild to moderate in intensity. About three fourths of the patients had either a swelling or a palpable mass and this, combined with pain, usually was their reason for seeking medical attention. The presence of a mass usually was the only physical finding of note. Laboratory examination of the blood and urine was of no help in making a diagnosis except that, in those cases in which it was done, the erythrocyte sedimentation rate was noted to be consistently elevated.

TABLE II

DISTRIBUTION BY AGE

Age (*Years*)	Solitary Lesions		Multiple Lesions	
	No. of Patients	Per cent.	No. of Patients	Per cent.
0–9	1	2.6	0	0
10–19	4	10.3	0	0
20–29	10	25.5	5	50.0
30–39	4	10.3	1	10.0
40–49	8	20.5	1	10.0
50–59	8	20.5	3	30.0
60–69	4	10.3	0	0
Total	39	100.0	10	100.0
Mean	39 years		37 years	
Youngest	Male, 9 years		Female, 22 years	
Oldest	Female, 68 years		Female, 55 years	
Ratio of male to female	28:11 = 2.5		7:3 = 2.3	

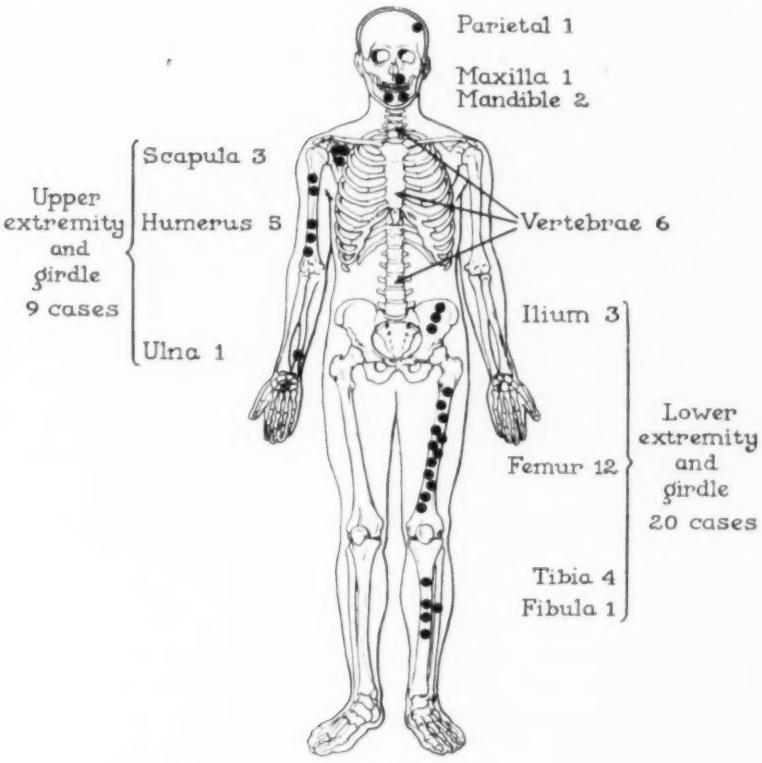

FIG. 5

Showing the anatomical distribution of reticulum-cell sarcoma of bone in thirty-nine cases.

In the papers of Sherman and Snyder, and of Coley, Higinbotham, and Groesbeck, as well as in an earlier report in which the authors participated [2], the roentgenographic appearance of this lesion as it involves bone was described. The roentgenographic ap-

TABLE III

DURATION OF SYMPTOMS

Duration *	Solitary Lesions		Multiple Lesions	
	No. of Patients	Per cent.	No. of Patients	Per cent.
< 6 months	11	28.2	3	30.0
6 months to < 1 year	12	30.7	2	20.0
1 year to < 2 years	9	23.1	2	20.0
2 years to < 3 years	3	7.7	1	10.0
3–4 years	1	2.6	2	20.0
5 to 9 years	2	5.1	0	0
10 years or more	1	2.6	0	0
Total	39	100.0	10	100.0
Mean	1.4 years		1.4 years	

* Of solitary lesions, prior to first examination; of multiple lesions, since appearance of first lesion.

FIG. 6

FIG. 7

Fig. 6: Reticulum-cell sarcoma of scapula.
Fig. 7: Reticulum-cell sarcoma of proximal part of femur.

pearance recently has been extensively studied also by Wilson. All of these authors agree that there is nothing distinctive about the roentgenogram of reticulum-cell sarcoma of bone; the usual picture is that of the osteolytic destruction seen in the presence of so many pathological conditions of bone (Figs. 6, 7, 8, and 9).

FIG. 8

FIG. 9

Fig. 8: Reticulum-cell sarcoma of distal part of femur.
Fig. 9: Reticulum-cell sarcoma of cuboid and adjacent bones.

TABLE IV

SURVIVAL RATES IN PATIENTS WITH SOLITARY LESIONS

Period of Survival (*Years*)	No. of Patients	No. Traced	Survival beyond Indicated Period	
			No.	Per cent.*
1	37	36	26	72.2
3	32	31	16	51.6
5	29	28	10	35.7

* Based on patients traced as of December 1, 1952. The one-year group includes only those patients whose condition was diagnosed at the Clinic in 1951 or earlier; the three-year group, those whose condition was diagnosed in 1949 and earlier; and the five-year group, those whose condition was diagnosed in 1947 and earlier.

Treatment in these cases included amputation, simple excision, administration of Coley's toxins, and roentgen or radium therapy. In many of the cases more than one type of treatment was used; amputation and subsequent roentgen therapy was the combination most frequently employed. It must be remembered that many of the patients were first examined twenty or more years ago, and many of them were thought to present either "round-cell sarcoma" or Ewing's tumor. Only in recent years (and in relatively few cases) was the proper diagnosis of reticulum-cell sarcoma made initially and treatment directed accordingly. Since the total series is small, these considerations make any definite conclusions impossible at this time; no one method of treatment can be unequivocally recommended.

Reticulum-cell sarcoma of bone is known to be highly radiosensitive at times. Brief reports of two cases from this series are illustrative of this:

CASE 1. A boy, eleven years of age, was brought to the Clinic because of painful swelling of the left shoulder of three months' duration. Examination disclosed a destructive lesion of the inferior angle and vertebral border of the scapula. A specimen taken for biopsy originally was thought to have come from a Ewing's tumor, but review has shown the tissue to be characteristic of reticulum-cell sarcoma. One course of roentgen therapy was given immediately after biopsy. No other treatment was given and the patient was known to be alive and well fifteen years later.

CASE 2. A boy, thirteen years old, was brought to the Clinic, complaining of occasional, moderately severe pain in the right arm. Examination disclosed a destructive lesion of the lower part of the right humerus. Symptoms had been present for six months. Local roentgen therapy was administered and the patient was known to be alive and well fifteen years later.

In these two cases the outcome was happy. However, much more frequent in the series were cases in which, notwithstanding roentgen or radium therapy, either alone or in conjunction with surgical operation, the outcome was death.

Several of the patients treated in earlier years were given Coley's toxins and, in the following case, there appeared to be a dramatic response.

CASE 3. A man, thirty-three years of age, complained of swelling of the left knee of four months' duration. Examination revealed decreased density of a portion of the medial femoral condyle. At biopsy a large mass of soft tissue which surrounded the femur was discovered. Coley's toxins were administered without any other treatment. The patient is known to be alive twenty-nine years later, with no evidence of disease. Review of the tissue has shown it to be typical of reticulum-cell sarcoma.

Coley's toxins do not appear to have been unmistakably effective in any other case of the series.

At present we are advising amputation or radical excision followed by roentgen therapy applied locally and to regional lymph nodes. We believe that this form of treatment offers the patient the best chance of survival. We are also sufficiently impressed by results in some of the earlier cases in which Coley's toxins were administered and, in recent months, we have added administration of the toxins to treatment of this lesion.

In Table IV are given the survival rates of patients in whom the lesions were solitary. It is to be noted that the five-year survival rate of 35.7 per cent. is somewhat better than the rate for most other primary malignant tumors of bone but is distinctly lower than the rate reported by Coley, Higinbotham, and Groesbeck. Of the smaller group of ten patients who presented multiple lesions on admission, eight are known to be dead. Of these eight patients, three (37.5 per cent.) lived five or more years following diagnosis.

SUMMARY

In a survey of 2,000 specimens of primary tumor of bone, forty-nine were found to be reticulum-cell sarcomata. The survey reinforced our conception that reticulum-cell sarcoma is a firmly established entity. It is important to establish the diagnosis by adequate biopsy. Unlike most other primary malignant conditions of bone, reticulum-cell sarcoma appears to be radiosensitive and, in one case in which the tumor disappeared, administration of Coley's toxins was the only treatment. At present, it appears that the prognosis in cases of reticulum-cell sarcoma of bone is significantly better than that in most other primary malignant tumors of bone.

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DISCUSSION

Dr. Mary S. Sherman, New Orleans, Louisiana: No one now would disagree with Dr. Compere's contention that it is foolhardy to attempt treatment of large giant-cell tumors by x-ray irradiation alone. I would go further and say that all accessible giant-cell tumors should be treated surgically. How radical the surgery should be is, of course, determined by how much faith the surgeon has in his ability to tell a benign from a potentially or frankly malignant lesion. Many of us do not agree with Lichtenstein that there are "grades" of malignancy, and some of us even wonder whether the benign lesions are tumors at all. At any rate, I for one do not find it as easy as Lichtenstein does to make a long-term prognosis in a given case. For that reason I believe that we should treat these lesions by curettage or wide local resection unless sarcomatous changes are evident. In that event, I believe the lesion is not a giant-cell tumor at all and therefore outside the bounds of this discussion.

Of course it is true that the mere presence of giant cells is not diagnostic and the other papers in this Symposium certainly prove this point.

The paper by Dr. Dahlin, Dr. Wells, and Dr. Henderson on Chondromyxoid Fibroma of Bone is especially apt in pointing out the importance of good pathological studies. Here is a lesion with a name which is far more formidable than its behavior. Whether one considers it as a distinct entity and a benign one or as a low form of chondrosarcoma, it is important that it be identified, since it is susceptible to cure. However, I wonder about the wisdom of curettage in any tumor of chondromatous origin. Such tumors have a way of reacting disagreeably to any disturbance. Since this is such a real danger it seems to me that one is not justified in recommending anything less than total excision.

Regarding the paper by Dr. Ivins and Dr. Dahlin on Reticulum-Cell Sarcoma of Bone, I am slightly disturbed to discover that others find the diagnosis of reticulum-cell sarcoma so easy that they consider reticulum stains of no help. It may be that there are many tumors in which the diagnosis is clear with routine stains, but I would prefer to see those fibers. Even then I find it troublesome to state with certainty that a given lesion is a reticulum-cell sarcoma. However, I think the most important point of this paper is the idea that, although most such tumors are highly radiosensitive, it is probably not wise to rely on x-ray irradiation alone. I am sure that surgical excision is best, although amputation can often be avoided by wide local resection.

(*Continued on page 866*)

LUXATIO COXAE CONGENITA

A Follow-up Study of Four Hundred and Six Cases of Closed Reduction* †

BY EIVIND PLATOU, M.D., OSLO, NORWAY

From the Orthopaedic Hospital, Oslo

The treatment of luxatio coxae congenita is not yet agreed upon, as is apparent from the abundant literature and the great variation in methods of reduction and subsequent treatment.

No one has reported ideal results. As neither the grouping of the early results at the conclusion of treatment nor that of the late results is standardized, comparison of the results of different authors is difficult. It is to be hoped that the system of Severin and Ponseti will be generally adopted, as this would afford a basis which would make possible a comparison of results and would allow definite conclusions to be drawn from the larger compilations of material, which would indicate what one should and should not do.

The only point on which there is agreement is that reduction should be performed around the age of one year. Efforts are being made, through mass x-rays, to make the diagnosis at the age of three to five months, so that in children in whom there is dislocation or danger of dislocation, the lower extremities may immediately be fixed to an abduction splint. Some authors claim that open reduction is the most comfortable for the patient and employ this method systematically in all cases, while the majority reserve this operation for cases in which a safe and stable closed reduction has not been possible.

I shall not go into detail as to the various methods of reduction as these have been clearly and concisely reviewed by Jones.

The value of the material to be reported on here lies in the fact that the author has personally reduced the large majority of the dislocations and has supervised the subsequent therapy in all cases. This treatment was carried out systematically and without any variations during the period 1934 to 1947 on 277 children with a total of 406 dislocated hip joints. The material includes only those cases which were suitable for closed reduction, and in which no attempts at reduction had been made at other hospitals previously. The forty-four hips treated by open reduction during the same period have been reported previously [10].

TREATMENT

Reduction is performed under ether as gently as possible, the head being lifted into the acetabulum over the posterior rim by the method of Schanz and Fairbank. A plaster bandage is then applied from the costal arch to the toes in Lorenz' position: 90 degrees of abduction, 90 degrees of flexion and usually slight pronation in the hip joint, and 90 degrees of flexion of the knee joint.

Stage I: After three months the plaster is removed and the extremity is lowered about 30 degrees and pronated 30 degrees.

Stage II: After one month the plaster is shifted again and the extremity is lowered an additional 30 degrees and pronated another 30 degrees.

If a control x-ray made five to six days after reduction shows that the position is satisfactory, the child is sent home. He is allowed to go home after each application of plaster. The care of the child presents no problems when he is placed on a box (Fig. 1). The child is laid on his stomach for a few hours each day.

* Read at the meeting of the Nordisk Ortopedisk Forening, Oslo, June 13, 1952.
† Received for publication September 12, 1952.

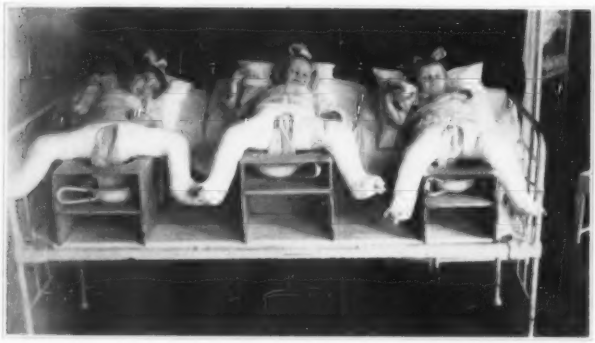

FIG. 1

Immobilization in plaster; from left, primary plaster, Stage I and Stage II.

After one month in Stage II, the plaster is again removed and the child is placed in a plaster mold, with 30 degrees' abduction of the hips and about 10 to 15 degrees' pronation and full extension of the hip and knee joints. During this period the child must spend about two and a half months at the clinic.

The child is taken up every day for massage and active and passive movements of the hip joint—always under x-ray control. If the position is satisfactory after one month in the plaster mold, the child is allowed up on a tricycle, the seat of which is extended on both sides with sloping boards so that the extremities are held in 30 degrees of abduction. After another month the child begins to walk. The hip has by this time been relieved of weight-bearing for seven months.

TABLE I

A. Summary of Cases

	No.	*Per cent.*		
Boys	48	17.3		
				277 patients
Girls	229	82.7		
Unilateral involvement				
Right		63		
Left		85		
Total			148	
Bilateral involvement			258	
Total				406 hips

B. Age Distribution at Reduction

	Age in Years					
	0 to 1 (*No. of Hips*)	1 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total
Unilateral involvement	3	72	40	14	19	148
Bilateral involvement	1	64	43	13	8	129
Total	4	136	83	27	27	277

C. Age at Follow-up Examination

Age (*Years*)	No. of Patients
4 to 8	90
8 to 13	107
13 to 18	62
18 and over	18

TABLE II

RESULTS AT FOLLOW-UP EXAMINATION

Result	Unilateral Dislocation *No. of Hips*	*Per cent.*	Bilateral Dislocation *No. of Hips*	*Per cent.*	Total No. of Hips	Per cent. of Series
A. Clinical Evaluation						
Good (Groups A, B, and C)	125	84.4	203	78.7	328	80.8
Poor (Groups D, E, and F)	23	15.6	55	21.3	78	19.2
Total	148	100.0	258	100.0	406	100.0
B. Roentgenographic Evaluation						
Good (Groups I, II, and III)	100	67.6	168	65.1	268	66.0
Poor (Groups IV, V, and VI)	48	32.4	90	34.9	138	34.0
Total	148	100.0	258	100.0	406	100.0

C. Anatomical Cures

	No. of Hips	*Per cent.*
Unilateral involvement	21	14.2
Bilateral involvement	38	14.7

In the large majority of cases this routine treatment has been successfully carried out. In a few cases the period in plaster had to be prolonged, especially during the first years covered by this report, when we had not yet understood the significance and treatment of anteversion [11], and had not yet performed open reduction as frequently as in later years.

To facilitate comparison with the results published by other authors, the material has been classified according to the system of Severin and Ponseti.

The results recorded here are not the end results; none of the patients is at present more than twenty years old. Not until this material has been checked up in another ten years will it be possible to obtain a correct impression of the therapeutic results, for even after the age of twenty regressive changes may take place as a result of the congenital dysplasia.

Because of the great distances in Norway—many of the patients have four to five days' journey to Oslo—the author personally made the follow-up examinations on only one fifth. For the remainder the following form was sent to the nearest hospital, which returned it together with roentgenograms:

Clinical Result

Unilateral: Reduced:
Bilateral: Check-up:
Name: Date of Birth:

A. No limp, no pains, normal movement.
B. No limp, but the patient "feels" his hip after exertion.
C. Slight limp, but no other symptoms.
D. Limps, tires quickly, but has good function in hips. Cannot walk more than two to three miles.
E. Always limps, tires easily, can walk only half a mile.
F. Always limps, hip is always troublesome.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Group I. Girl twenty-one months old. Roentgenogram made before reduction. Note the very slanting acetabular roof.
Fig. 2-B: Roentgenogram made at conclusion of treatment.

In the period 1934 to 1947 we treated 297 children by closed reduction. It has been possible to make control examinations of 277 of these, 93.2 per cent., and these are the cases which are described here.

The material is divided into two main groups: (1) according to the clinical results, as classified in the form above; (2) according to the roentgenographic results.

The roentgenographic result was in every case determined personally by the author according to the following system:

Roentgenographic Result

I. Normal hip: CE angle more than 15 degrees between six and thirteen years.
CE angle more than 20 degrees at fourteen years or more (Figs. 2-A to C-2).
II. Moderate deformity of the head, neck, and acetabulum. CE angle as under I (Figs. 3-A to 3-C).
III. Dysplasia but no subluxation. CE angle less than 15 degrees between six and thirteen years. CE angle less than 20 degrees at fourteen years or more (Figs. 4-A to 4-C).
IV. Subluxation (Figs. 5-A to 5-C).
V. Head in new acetabulum in upper part of the old one (Figs. 5-A to 5-C).
VI. Reluxation (Figs. 6-A to 6-C).

The CE angle was calculated according to the method described by Wiberg.

Table I presents a summary of the material covered by this report. The results at the follow-up examination are presented in Table II.

Early Results

The early result is obviously decisive for the late result. Early results are classified in Table III according to the roentgenographic findings and age at reduction.

Clinical results cannot be recorded at the time of treatment, as the children have barely learned to walk when the treatment is concluded.

FIG. 2-C

Roentgenogram made thirteen years after reduction. Note the good development of the originally very slanting acetabular roof.

If Groups I, II, and III in Table III are combined, we find that good results were obtained in 371 hips, or 91.4 per cent.; if Groups IV, V, and VI are combined, we see that poor results were obtained in thirty-five hips, or 8.6 per cent.

The reason we have had poor results in as many as thirty-five hip joints is partly that we were not able to cope with anteversion during the first eight to ten years, and partly because we did not perform open reduction as frequently as we do now. The follow-

FIG. 3-A

Group II. Girl twenty-one months old. Roentgenogram made before reduction.

FIG. 3-B

Roentgenogram made at conclusion of treatment.

FIG. 3-C

Roentgenogram made thirteen years after reduction. Both femoral heads were slightly flat. The left head was slightly high in the acetabulum.

up examinations revealed that five of these thirty-five hip joints have improved, so that they are now moved up into Groups II or III.

Age at Reduction

As already mentioned, there is today complete agreement that reduction should be

FIG. 4-A

Group III. Girl, twenty-two months old. Roentgenogram made before reduction.

performed about the age of one year, or at least before the age of two. Late clinical results according to age groups in unilateral and bilateral dislocations are shown in Tables IV and V. The figures are so small that the percentile values are not significant, but have been calculated to give a general impression (Table XII).

The figures are somewhat different, if we compile the roentgenographic results (Tables VII through X).

Compiling the material in Tables VII through X, we obtain in Table XI a summary

FIG. 4-B

Roentgenogram made at conclusion of treatment.

FIG. 4-C

Roentgenogram made fifteen years after reduction. The left head was somewhat deformed.

TABLE III

SUMMARY OF EARLY ROENTGENOGRAPHIC RESULTS IN 406 HIP JOINTS

Result	Age at Time of Reduction (Years) 0 to 1 (No. of Hips)	1 to 2 (No. of Hips)	2 to 3 (No. of Hips)	3 to 4 (No. of Hips)	Over 4 (No. of Hips)	Total (No. of Hips)	
Group I	1	18	15	2		36	
Group II	1	76	50	20	13	160	
Group III	3	91	53	13	15	175	
Total							371
Group IV		14	6	5	2	27	
Group V					3	3	
Group VI		1	2		2	5	
Total							35
Total	5	200	126	40	35		406

TABLE IV

LATE CLINICAL RESULTS IN UNILATERAL DISLOCATIONS

Result	Age at Time of Reduction (Years) 0 to 2 (No. of Hips)	2 to 3 (No. of Hips)	3 to 4 (No. of Hips)	Over 4 (No. of Hips)	Total (No. of Hips)	
Group A	48	24	5	4	81	
Group B	5	3	2	3	13	
Group C	13	9	5	4	31	
Total						125 (84.4 per cent.)
Group D	3	3	2	2	10	
Group E	2				2	
Group F	4	1		6	11	
Total						23 (15.6 per cent.)

TABLE V

LATE CLINICAL RESULTS IN BILATERAL DISLOCATIONS

Result	Age at Time of Reduction (Years) 0 to 2 (No. of Hips)	2 to 3 (No. of Hips)	3 to 4 (No. of Hips)	Over 4 (No. of Hips)	Total (No. of Hips)	
Group A	98	38	13	5	154	
Group B	4	4	3	1	12	
Group C	16	13	3	5	37	
Total						203 (78.7 per cent.)
Group D	9	14	4	2	29	
Group E			1		1	
Group F	3	17	2	3	25	
Total						55 (21.3 per cent.)

of all the cases with good roentgenographic results. It appears that there is no significant difference among the various age groups at the conclusion of treatment, and unilateral and bilateral dislocations give almost the same results.

At the follow-up examination the age at reduction was found to be significant, as the best results are obtained in the group from infancy to two years. The discrepancy in the group from three to four years is probably accidental because of the small numbers.

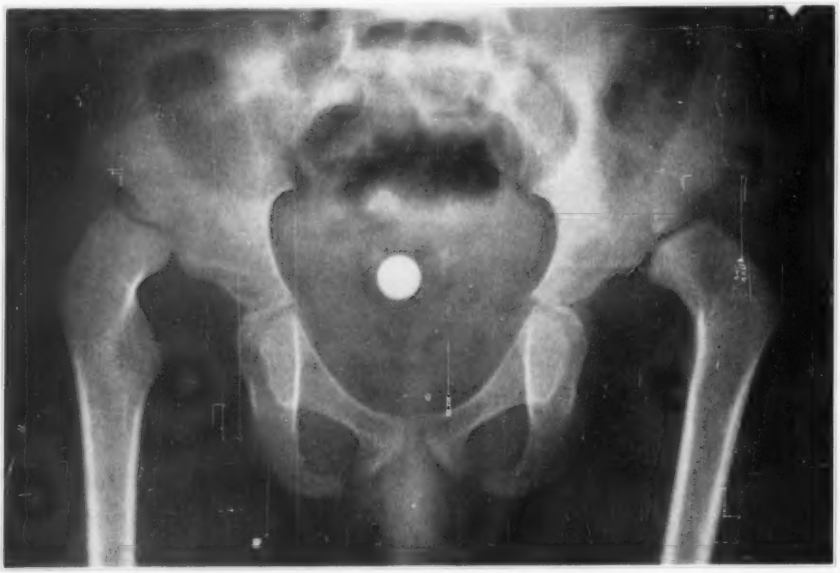

FIG. 5-A

Groups IV and V. Boy aged three years and five months. Roentgenogram made before reduction.

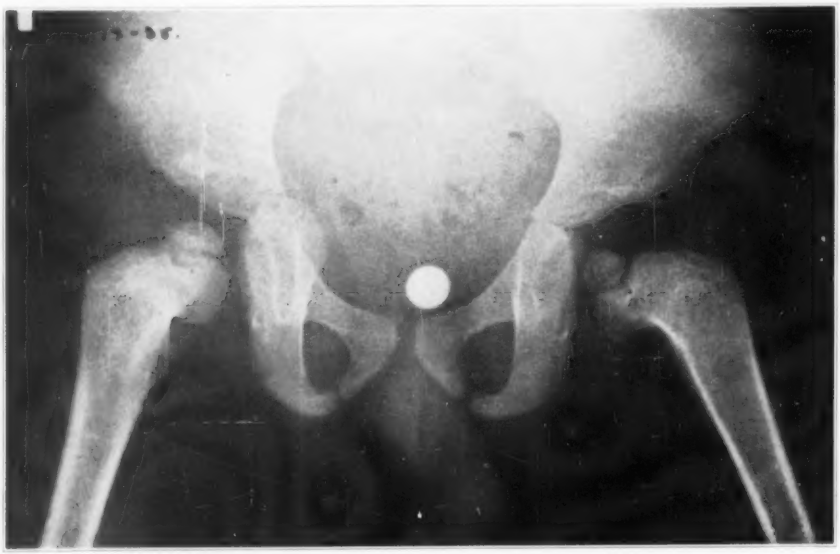

FIG. 5-B

Roentgenogram made at conclusion of treatment.

TABLE VI

GOOD LATE CLINICAL RESULTS (GROUPS A, B, AND C) ACCORDING TO AGE AT REDUCTION

Age at Reduction (*Years*)	Unilateral Dislocation (*Per cent.*)	Bilateral Dislocation (*Per cent.*)
0 to 2	88.0	90.7
2 to 3	90.0	63.9
3 to 4	85.7	73.1
Over 4	57.9	68.7

FIG. 5-C

Roentgenogram made sixteen years after reduction. The right hip showed subluxation (Group IV). In the left hip the head was in the new acetabulum, which formed the upper part of the old (Group V).

TABLE VII

ROENTGENOGRAPHIC RESULTS AT CONCLUSION OF TREATMENT IN UNILATERAL DISLOCATIONS

Result	Age at Time of Reduction (*Years*) 0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group I	7	5	1		13	
Group II	32	19	5	8	64	
Group III	33	15	7	6	61	
Total						138 (93.2 per cent.)
Group IV	2		1	1	4	
Group V				3	3	
Group VI	1	1		1	3	
Total						10 (6.8 per cent.)

TABLE VIII

LATE ROENTGENOGRAPHIC RESULTS ACCORDING TO AGE AT REDUCTION IN UNILATERAL DISLOCATIONS

Result	Age at Time of Reduction (*Years*) 0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group I	13	6	2		21	
Group II	34	17	5	4	60	
Group III	10	1	4	4	19	
Total						100 (67.6 per cent.)
Group IV	16	10	3	2	31	
Group V	1	2		5	8	
Group VI	1	4		4	9	
Total						48 (32.4 per cent.)

TABLE IX

ROENTGENOGRAPHIC RESULTS AT CONCLUSION OF TREATMENT IN BILATERAL DISLOCATIONS

Result	Age at Time of Reduction (*Years*) 0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group I	12	10	1		23	
Group II	45	31	15	5	96	
Group III	61	38	6	9	114	
Total						233 (90.0 per cent.)
Group IV	12	6	4	1	23	
Group V					0	
Group VI		1		1	2	
Total						25 (10.0 per cent.)

TABLE X

LATE ROENTGENOGRAPHIC RESULTS ACCORDING TO AGE AT REDUCTION IN BILATERAL DISLOCATIONS

Result	Age at Time of Reduction (*Years*) 0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group I	28	9	1		38	
Group II	54	29	4	1	88	
Group III	20	12	5	5	42	
Total						168 (65.1 per cent.)
Group IV	25	15	11	4	55	
Group V	2	11	3	5	21	
Group VI	1	10	2	1	14	
Total						90 (34.9 per cent.)

Table XI shows that the roentgenographic results also grow poorer after several years, slightly more so in the bilateral than in the unilateral cases.

It is well known that no definite conclusions as regards the clinical result—the func-

TABLE XI

GOOD ROENTGENOGRAPHIC RESULTS

Age at Reduction (*Years*)	At Conclusion of Treatment (*No. of Hips*)	(*Per cent.*)	At Follow-up Examination (*No. of Hips*)	(*Per cent.*)
		Unilateral Dislocations		
0 to 2	72	96.0	57	76.0
2 to 3	39	97.5	24	60.0
3 to 4	13	92.9	11	78.6
Over 4	14	73.6	8	42.1
Total	138		100	
		Bilateral Dislocations		
0 to 2	118	90.7	102	78.4
2 to 3	79	91.8	50	58.1
3 to 4	22	84.6	10	38.4
Over 4	14	87.5	6	37.5
Total	233		168	

TABLE XII

COMPARISON OF GOOD CLINICAL AND GOOD ROENTGENOGRAPHIC LATE RESULTS

Age at Reduction (*Years*)	Unilateral		Bilateral	
	Clinical (*Per cent.*)	Roentgenographic (*Per cent.*)	Clinical (*Per cent.*)	Roentgenographic (*Per cent.*)
0 to 2	88.0	76.0	90.7	78.4
2 to 3	90.0	60.0	63.9	58.1
3 to 4	85.7	78.6	73.1	38.4
Over 4	57.9	42.1	68.7	37.5

TABLE XIII

EARLY ROENTGENOGRAPHIC RESULTS IN SIXTY-FOUR PATIENTS OVER FOURTEEN YEARS OLD AT FOLLOW-UP EXAMINATION

Result	Age at Time of Reduction (*Years*)					
	0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group I	3	3	1		7	
Group II	4	12	10	9	35	
Group III	15	11	4	7	40	
Total						82 (86.3 per cent.)
Group IV	3	2	1	2	8	
Group V				1	1	
Group VI		2		2	4	
Total						13 (13.7 per cent.)

tion of the hip joint—can be drawn from an x-ray. If good clinical and good roentgenographic late results are compared, as in Table XII, we see that the clinical result—and that is what counts—is much better than the roentgenographic result.

When these patients are seen again after ten years, the number of good results will undoubtedly have decreased. In order to find out whether this material gives any indications in that direction, the patients who were fourteen years old or more at the time of

FIG. 6-A

Group VI. Girl two and one half years old. Roentgenogram made before reduction.

FIG. 6-B

Roentgenogram made at conclusion of treatment, showing pathological anteversion bilaterally. In a similar case today, rotation osteotomy would be performed.

FIG. 6-C

Roentgenogram made fifteen years after reduction, showing recurrence of dislocation bilaterally.

follow-up examination were considered separately. There were sixty-four patients with a total of ninety-five dislocated hip joints, with a follow-up period from ten to sixteen years.

FIG. 7

Roentgenogram showing degree of displacement in Grade 1.

TABLE XIV

LATE CLINICAL RESULTS IN SIXTY-FOUR PATIENTS OVER FOURTEEN YEARS

Result	Age at Time of Reduction (*Years*) 0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group A	19	11	7	5	42	
Group B	1	3	4	2	10	
Group C	2	3	1	7	13	
Total						65 (68.4 per cent.)
Group D	2	5	3	3	13	
Group E					0	
Group F	1	10	1	5	17	
Total						30 (31.6 per cent.)

TABLE XV

LATE ROENTGENOGRAPHIC RESULTS IN SIXTY-FOUR PATIENTS OVER FOURTEEN YEARS

Result	Age at Reduction (*Years*) 0 to 2 (*No. of Hips*)	2 to 3 (*No. of Hips*)	3 to 4 (*No. of Hips*)	Over 4 (*No. of Hips*)	Total (*No. of Hips*)	
Group I	8	4	2		14	
Group II	11	8	4	3	26	
Group III	4	1	4	6	15	
Total						55 (57.9 per cent.)
Group IV	1	3	4	4	12	
Group V	1	8		7	16	
Group VI		8	2	2	12	
Total						40 (42.1 per cent.)

The primary roentgenographic results are presented in Table XIII. They are somewhat poorer than for the material as a whole, as this group includes most of the children who were more than four years old when treatment was begun. They represent twenty-one hip joints of the total ninety-five.

In the series as a whole there were good results in 91 per cent. In the group over fourteen there were good results in 86 per cent. The late clinical results are presented in Table XIV. The late roentgenographic results are presented in Table XV. Late clinical results were good in 81 per cent. of the series. Late clinical results were good in 68 per cent. in the group over fourteen. Late roentgenographic results were good in 66 per cent. of the series. Late roentgenographic results were good in 58 per cent. of the group over fourteen. The late clinical results in the older group were thus considerably poorer than in the series as a whole.

As the child grows up, the demands on the function of the hip joint increase and defects which played little or no role in childhood begin to make themselves felt.

The roentgenographic results, on the contrary, have held fairly well. This may indicate that the dysplasia increases mainly during the first ten years after reduction.

The number recorded as anatomically cured among these ninety-five hip joints is fourteen, or 14.6 per cent. In the series as a whole the corresponding figure is 14.5 per cent. This shows that once a normal hip joint has been obtained, it does not become altered with time.

TABLE XVI

STATUS OF FEMORAL HEAD

	No. of Cases	Per cent.
Before reduction		
Normal bone nucleus	230	56.7
Little or no bone nucleus	176	43.3
At conclusion of treatment		
Of 230 normal, 140 remained normal		60.8
Of 176 defective, 86 were normal		43.1
At follow-up examination		
Of 230 normal, 81 remained normal		35.2
Of 176 defective, 47 were normal		26.7

TABLE XVII

ACETABULAR ANGLE

	10 to 30 degrees (*No. of hips*)	30 to 35 degrees (*No. of hips*)	35 to 40 degrees (*No. of hips*)	40 degrees or more (*No. of hips*)	Total
Unilateral Dislocations					
Before reduction	4	19	45	80	148
Up to six years later	25	16	5	5	51
More than six years later	49	10	10	28	97
Bilateral Dislocations					
Before reduction	4	26	79	149	258
Up to six years later	26	17	9	2	54
More than six years later	90	26	19	69	204

Naturally, the parents of the children always ask us if we can promise anything about the result of the treatment. Does this material offer any basis for conclusions as to the prognosis?

Excluding those children who have multiple defects and extreme dysplasia, the following factors will be significant:

1. *Age:* The earlier the child is treated, the better the prognosis;
2. The *anatomy* of the head and neck, as seen roentgenographically;
3. The *acetabular angle;*
4. The *degree of displacement*, as seen roentgenographically;
5. *Injury* at reduction.

Unsuccessful reduction with subsequent open reduction is not included here.

The Femoral Head

From the age of one year there is normally a distinct bone nucleus in the head, but in children with luxatio coxae it varies both as to size and form and may be entirely absent up to the age of three.

A comparison of this material is given in Table XVI. These figures show that more than half (56.7 per cent.) of the hip joints have a normal femoral head before reduction, while in 43.3 per cent. the head shows pathological changes. If we follow the fate of these

TABLE XVIII

LATE ROENTGENOGRAPHIC RESULTS IN HIP JOINTS WITH AN ACETABULAR ANGLE OF MORE THAN 40 DEGREES BEFORE REDUCTION

	Unilateral Dislocation		Bilateral Dislocation	
Group I	10		17	
Group II	31		39	
Group III	12		31	
Total		53 (66.2 per cent.)		87 (58.3 per cent.)
Group IV	17		42	
Group V	6		12	
Group VI	4		8	
Total		27 (33.7 per cent.)		62 (41.6 per cent.)

TABLE XIX

DEGREE OF DISPLACEMENT AND LATE RESULTS

Degree of Displacement	Groups I, II, and III	Groups IV, V, and VI	Good Results (*Per cent.*)
Unilateral			
Grade 1	16	6	72.7
Grade 2	42	10	80.7
Grade 3	38	36	51.3
Bilateral			
Grade 1	35	4	89.7
Grade 2	31	12	72.1
Grade 3	101	75	57.3

bone nuclei, we find that there is a marked difference in development. Among the originally normal bone nuclei, 60.8 per cent. were still normal at the conclusion of treatment, while only 43.1 per cent. of the pathologically involved nuclei became normal. The same difference is encountered again at the follow-up examination. Here we find that of 230 normal bone nuclei 34.7 per cent. were still normal, while of 176 pathologically involved nuclei only 26.7 per cent. became normal.

Prognostically it can be said that children with normal bone nuclei have a better chance for a good result of the treatment than those who start out with involved bone nuclei. The difference is not great, however, and we have several examples of children with originally severely involved bone nuclei who have become anatomically cured.

The evaluation of the femoral neck is so uncertain in these small children that no attempt has been made at classification.

The Acetabular Angle

Of 406 hip joints there were only eight, or 2 per cent., which had a normal acetabular angle of less than 30 degrees before reduction. In 54 per cent. of the cases with unilateral and in 58 per cent. of the cases with bilateral dislocation a very steep acetabular roof of over 40 degrees was found.

The exact distribution of the acetabular angle and its development is presented in Table XVII.

One would expect that a very steep acetabular roof would indicate a poorer prognosis, but this is not the case. Table XVIII shows the late results in all the hip joints which had an acetabular angle of 40 degrees or more before reduction.

Good late roentgenographic results were obtained in 67.5 per cent. of the total number

of unilaterally dislocated hips, and in 66.2 per cent. of eighty hip joints with an acetabular angle of more than 40 degrees.

For all 258 hips with bilateral dislocation the corresponding figure is 65.1 per cent.,

FIG. 8

Roentgenogram showing degree of displacement in Grade 2.

FIG. 9

Roentgenogram showing degree of displacement in Grade 3.

TABLE XX

EFFECT OF REDUCTION ON FEMORAL HEAD

	No.	Per cent.
Easy Reduction		
Normal head before reduction	192	
Normal head at conclusion of treatment	125	65.1
Normal head at follow-up examination	77	40.1
Difficult Reduction		
Normal head before reduction	38	
Normal head at conclusion of treatment	15	39.4
Normal head at follow-up examination	4	10.5
Easy Reduction		
Small head or none before reduction	141	
Normal head at conclusion of treatment	76	53.9
Normal head at follow-up examination	43	30.5
Difficult Reduction		
Small head or none before reduction	35	
Normal head at conclusion of treatment	10	28.5
Normal head at follow-up examination	4	11.4

and for 149 hips with an acetabular angle of more than 40 degrees it is 58.3 per cent.

The difference is so small that it can be said that the acetabular angle before reduction does not have much significance for the late results.

Degree of Displacement

Arthrography has not been employed in this material, so that we have no definite evidence whether a head was completely dislocated (that is, whether it was above the limbus) or whether it was subluxated (that is, under the limbus).

Hilgenreiner's measurement in millimeters of the position of the head in relation to the Y cartilage affords no definite information, and has not been made in this series.

For clarity, the degree of displacement has been classified into Grades 1, 2, and 3; these are illustrated in Figures 7, 8, and 9.

Grade 1 includes all of those femoral heads which are definitely under the limbus; in Grade 2 probably about half of them are under the limbus, and in Grade 3 all are entirely dislocated, that is, above the limbus.

In order to determine whether the degree of displacement influences the late results, all of the hip joints have been classified as shown in Table XIX.

It appears from Table XIX that for unilaterally dislocated hips there was no significant difference in the results for Grades 1 and 2; 72.7 per cent. of the hips with Grade 1 displacement and 80.7 per cent. of the hips with Grade 2 displacement had good results. For bilateral affections there were better results than in those with Grade 2 displacement: 89.7 per cent. and 72.1 per cent. respectively.

Grade 3 reveals a considerably smaller percentage of good results for all hip joints, 51.3 per cent. in those with unilateral and 57.3 per cent. in those with bilateral dislocation.

Thus it appears that the degree of displacement has some prognostic value.

Effect of Trauma of Reduction

The femoral head is the cornerstone of the hip joint. A defective head will always lead to a defective joint. As we have seen in Table XVI, only about half of the bone nuclei of the femoral heads (56.7 per cent.) were normal at the beginning of treatment. At the conclusion of treatment about 56 per cent. were still normal, but as the years pass—in this material from three to sixteen years after reduction—the number of normal femoral heads decreases considerably; for these 406 hip joints it decreased to 29.7 per cent.

It might be possible to obtain better results by relieving these hips for a considerably

TABLE XXI

REDUCTION TRAUMA AND LATE ROENTGENOGRAPHIC RESULTS

	Total No. of Hips	Good Results (Groups I, II, and III)		Poor Results (Groups IV, V, and VI)	
		No.	*Per cent.*	*No.*	*Per cent.*
Easy Reduction	333	227	68.2	106	31.8
Difficult Reduction	73	36	49.3	37	50.7

TABLE XXII

"NORMAL" HIPS IN UNILATERAL DISLOCATION

Result	Roentgenographic Status at Discharge		Roentgenographic Status at Follow-up Examination	
Group I	88		108	
Group II	49		21	
Group III	6		6	
Total		143 (96.6 per cent.)		135 (91.2 per cent.)
Group IV	5		10	
Group V	0		3	
Group VI	0		0	
Total		5 (3.4 per cent.)		13 (8.8 per cent.)

longer period than the seven months of non-weight-bearing employed here, but if any attempts are made in this direction, they will have to be very radical. The child would have to be kept in plaster for twelve to fourteen months, followed by the two months in the mold and on the tricycle, a total period of about sixteen months as compared with the seven now employed.

When we see from Table XVI, however, that in a large number (39.1 per cent.) of the heads which were normal before reduction pathological changes had taken place at the conclusion of treatment, the factor of reduction trauma must be considered.

Any method of reduction will be injurious to the head. Advocates of routine open reduction claim that it is this injury which they avoid, or at least minimize considerably. I have found no convincing statistical evidence in the literature that in an extensive and uniform material there are fewer pathologically affected femoral heads after open than after closed reduction.

As already mentioned, we performed the reduction as gently as possible, and a note was made in the case records whether the reduction was easy or difficult. A difficult reduction involves considerable injury to the femoral head; the material has, therefore, been divided into four groups as shown in Table XX.

Table XX shows that reduction trauma undoubtedly plays a significant part. After an easy reduction 65.1 per cent. of the normal heads were still normal at the conclusion of treatment, as compared with only 39.4 per cent. after a difficult reduction. The difference is even more accentuated in those cases in which the head was defective before reduction. Here an easy reduction gave 53.9 per cent. and a difficult reduction 28.5 per cent. normal heads at the conclusion of treatment.

The late results show the same findings. An easy reduction gave normal heads in 40 per cent. of those with normal heads before reduction and in 31 per cent. of those with defective heads before reduction. A difficult reduction gave 11 per cent. of normal heads in both those with normal heads before reduction and those with defective heads before reduction.

We see from Table XXI that an easy reduction gives a somewhat better late roentgenographic result than a difficult reduction, 68.2 per cent. and 49.3 per cent. respectively.

Here the experience of the operator is of very great importance. An operator who has reduced several hundred dislocations will be able to replace the dislocated head with much less force than an operator who performs reductions only occasionally.

There are thus some prognostic reservations after a difficult reduction, even though the early result may be good.

It is surprising that so many of the contralateral hips became defective, although all of them were treated in the same manner as the involved hips.

Hip spicas on one side only have never been employed in this series. They are technically incorrect. One might say that some of these unilateral dislocations should have been classified as bilateral, and that is quite possible, but as all dislocations were treated as if they had been bilateral, the classification makes no difference, except that the percentage of good results in bilateral dislocations would have been higher.

Anteversion

In this material a pathological anteversion—that is, of more than 30 degrees—has been demonstrated in fifty-one patients with sixty hip joints, or 15 per cent. Roentgenograms made at follow-up examination showed that only eight of these hip joints were satisfactory. Among the other fifty-two hip joints were thirty subluxations and twenty-two reluxations.

We thus had poor roentgenographic results in 87 per cent. The corresponding figure for the entire material was 34 per cent.

The use of rotation osteotomy in connection with this complication has been discussed in a previous article[11].

Acetabuloplasty

This has been performed in nineteen cases with consistently poor results, partly because of resorption of the implanted pieces of bone, and partly and perhaps largely because of mistaken indications. In a number of cases, rotation osteotomy should have been performed instead of plastic surgery of the roof[3].

Complications

One fracture of the femoral neck and one subtrochanteric fracture occurred during reduction; both healed.

There was paralysis of the sciatic nerve in three cases, but this passed off in the course of two or three months.

As a result of the long period of immobilization, the bones become very brittle. When the children begin to go about, they are often pushed while at play or they have falls. Femoral infractions have occurred fifty times in this series. The femur cracks two finger-breadths above the knee, but there is never a true fracture, only a greenstick fracture.

The treatment is very simple. The infraction is set without an anaesthetic by means of steady pressure against a hard substratum, and a plaster cast is applied from the proximal end of the thigh to well along the calf. The treatment of the hip joint is continued in bed, where the child spends four weeks. By this time the infraction has healed.

Infraction of the tibia occurred twice.

COMMENTS

The purpose of follow-up examinations in a large series is to determine whether the results are satisfactory. If they are not, conclusions may be drawn as to changes which should be made in the method of treatment. If we consider the results as a whole as presented in Table I, we find that of 406 hips with a control period ranging from three to

thirteen years, clinically good results were obtained in 358 (80.8 per cent.) and roentgenographically good results were obtained in 268 hips, or 66 per cent.

In Tables XII and XIII we find that for sixty-four patients, with ninety-five hip joints, who were fourteen years or over at the time of follow-up examination, good functional results were obtained in 68 per cent. and good roentgenographic results in 58 per cent.

These figures are fully as satisfactory as those reported in the literature and our Clinic will not change its method of treatment at the present time.

Table III shows good early roentgenographic results in 91.4 per cent. In this material, as in other series, there are considerable regressive changes. Both the nature and the origin of the congenital dysplasia are unknown, and we have no control over it. The only solution might be, as already mentioned, to prolong the period of non-weight-bearing after reduction from seven months, as in the present material, to fourteen or twenty months, but this is hardly practicable.

An attempt has been made to ascertain the prognosis on the basis of findings at the beginning of treatment in this series. As regards age there is complete agreement—the younger the patient at the time of treatment, the better the result.

The Femoral Head

From several sources—especially German—it has been emphasized that a defective bone nucleus at the beginning of treatment does not offer a good prognosis. This has not been demonstrated in the present material; it can only be said that children with normal bone nuclei have somewhat better chances of a good result.

The Acetabular Angle

Surprisingly enough, this material seems to indicate that even a very large acetabular angle—40 degrees or more—has no significant influence on the late result.

Degree of Displacement

The severe dislocations (Grade 3) yield poorer results than the slighter ones (Grades 1 and 2); it can, therefore, be said that the degree of dislocation has some prognostic value.

Trauma of Reduction

Reduction trauma is undoubtedly of considerable significance. A difficult reduction involves greater injury to the femoral head, and the late results show that after an easy reduction there were good results in 68 per cent., as compared with 49 per cent. of good results after a difficult reduction.

There are thus prognostic reservations after a difficult reduction, even though the primary result may be good.

The conclusions to be drawn from this must be that, if an experienced operator cannot put the femoral head into position after two or three attempts, no further attempts should be made, and the hip should be reduced by surgery two weeks later.

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DISCUSSION

(*Continued from page 842*)

The Symposium as a whole underlines, as it should, the extreme importance of establishing an accurate microscopic diagnosis before definitive treatment is planned. It shows, too, especially in relation to the giant-cell tumors and bone aneurysms, that, in order to make a diagnosis, an adequate biopsy specimen is essential.

Dr. Murray M. Copeland, Washington, D. C.: Dr. Compere's was an excellent presentation. I certainly believe that a biopsy specimen should be obtained in every case of suspected giant-cell tumor. I believe that all true giant-cell tumors as such are benign, but roentgenographically it is difficult to determine whether metaplasia is taking place in the tumor. Occasionally a malignant change in the form of an osteogenic sarcoma may develop in a giant-cell tumor; this possibility should be ruled out by pathological examination. I further believe that surgery is the treatment of choice. The ultimate cosmetic and functional result in weight-bearing bones is best obtained by surgery alone, even to the extent of doing a resection, as Dr. Compere has pointed out. Irradiation will cure many of these tumors, but in weight-bearing bones it is less apt to give a completely satisfactory functional result. Irradiation over bone is followed occasionally by malignant metaplasia (osteogenic sarcoma) several years later.

In regard to the paper by Dr. Dahlin, Dr. Wells, and Dr. Henderson on Chondromyxoid Fibroma of Bone, I feel that basically these lesions are related to central chondromata of bone. In our experience central chondroma in the long bones, in the pelvis, and about the sternum, when incompletely removed, leads to a fatal termination in about 20 to 25 per cent. of the cases. The authors have presented an interesting group of tumors, but, from the standpoint of prognosis, I think we should not forget that we are dealing primarily with a central cartilaginous tumor.

The paper on Reticulum-Cell Sarcoma of Bone by Dr. Ivins and Dr. Dahlin was an excellent one. I was glad to note that these authors feel that Ewing's tumor is a scrap basket for a variety of round-cell tumors of bone which should have further investigation. It is interesting that the survival rate in reticulum-cell sarcoma of bone is shown to be higher; that the cells are much larger than those seen in Ewing's tumor; that there are some binucleate cells; that pleomorphism and similar phenomena are present; but that in general there are no specific symptoms. In the early phases of Ewing's tumor, together with uniform small round cells, we see proliferative bone reaction, but largely destructive bone features appear late in the course of the disease. In earlier studies, tumors composed of variations of this group of lesions were all spoken of as round-cell sarcomata of bone, large and small. The exact cell derivation of these round-cell sarcomata is still held *sub judice*. I prefer to think, therefore, of Ewing's tumor as originally described by Ewing as an entity and to designate the variations as atypical Ewing's tumor until more information is available on the cell of origin. We have a close counterpart of Ewing's tumor in round-cell sarcomata of the soft tissues. When we study reticulum-cell lymphosarcoma, variations in the pathological picture may simulate the lesions presented today. There is a question as to whether there is a stem cell by which we might correlate all of these groups, or whether we are actually dealing with a variety of tumor entities.

FRACTURES OF THE HIP IN CHILDREN

Treatment and Results*

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Fractures of the hip in children, although rare, are associated with an excessive incidence of complications in all reported series of cases. Those most commonly encountered are avascular necrosis, non-union, malunion, and disturbances in growth. A review of the literature on this subject reveals a wide divergence of opinion as to their incidence, their cause, and the methods of treatment most likely to prevent their development. The purpose of this investigation is to determine the end results of fractures of the hip in children treated by the Staff of the Campbell Clinic since 1930 and on the basis of the cases studied to make observations concerning the incidence, treatment, complications, and prognosis of such fractures.

Wilson, in an excellent article in 1940, reported that the maintenance of reduction of such fractures in a Whitman cast was difficult, but questioned the advisability of internal fixation because of possible damage to the epiphyseal plate and secondary disturbance of growth.

Carrell and Carrell in 1941 found in a study of twelve fractures of the hip that the Whitman method was inadequate, that nailing was undesirable, and that traction alone did not correct the deformity. They favored the combined method of traction and abduction, but emphasized the high incidence (33.3 per cent.) of avascular necrosis as a complication of these fractures.

Allende and Lezama, on the other hand, in 1951, based their indications for treatment on the obliquity of the fracture, finding that cases with a Pauwels angle of less than 50 degrees responded well to the Whitman technique, and that those fractures in which the Pauwels angle was greater than 50 degrees should be treated surgically. The recommended procedure consisted of an intertrochanteric femoral osteotomy to modify the direction of the fracture line. In their experience the final result was frequently malunion in a coxa vara position.

Colonna, in 1951, in discussing these fractures, felt that they were relatively simple to treat in the early stage, and that the abduction method of Whitman was still a very satisfactory form of treatment in this early age group. He agreed, however, with previous authors that late avascular necrosis is a frequent and serious complication.

RESULTS

This study is a critical analysis of all the known cases of fracture of the upper portion of the femur in patients less than seventeen years of age who have been treated by the Staff of the Campbell Clinic since 1930. It does not include three patients who sought treatment for complications of such fractures at the time of their original visit to the Campbell Clinic. A few of the patients treated prior to 1934 have also been included in an earlier report from this Clinic by Mitchell. The cases total twenty-four in number and the authors have personally examined the patients or their clinical records and roentgenograms, or both, within the past eighteen months.

Of the twenty-four patients studied, fourteen were males and ten were females. The age distribution ranged from two to sixteen years, the average being ten and three-tenths years at the time of injury. Several authors have previously noted that fractures of the hip in children are either the result of severe trauma or the result of a pre-existing patho-

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 26, 1953.

logical lesion which weakens the bone and permits it to be fractured by lesser degrees of trauma. This observation was substantiated in the present series of cases. The fracture was the result of severe trauma in seventeen cases and of moderately severe trauma in three cases. It was the result of lesser degrees of trauma being applied to an extremity weakened by a pre-existing pathological condition in four cases: poliomyelitis, two; fibrous dysplasia of the femur, one; and disuse atrophy from rheumatic fever, one.

An attempt was made to correlate the final results with the interval between injury and institution of definitive treatment in these cases but, because of the small number of cases and the large number of variable factors included in this group, it was not possible to establish a correlation of statistical value.

These cases were classified according to an anatomical classification developed by Delbet and subsequently used by most authors. Type I, or transepiphyseal, fractures occur at the level of the capital femoral epiphyseal line. This fracture is not to be confused with slipping of the capital femoral epiphysis; it is an acute traumatic separation of a previously normal epiphysis. Type II, or transcervical, fractures occur through the mid-portion of the femoral neck. Type III, or cervicotrochanteric, fractures occur at the base of the neck of the femur, and Type IV, or intertrochanteric, fractures occur between the base of the femoral neck and the lesser trochanter. Since the treatment and results differ in the four types, they are discussed separately.

Type I: Transepiphyseal Fractures

Six of the twenty-four patients under consideration (Table I) had suffered fractures through the proximal femoral epiphyseal plate and in five of the six cases the femoral head was also dislocated from the acetabulum. The patients in this group obtained by far the poorest results regardless of the method of treatment used, only one acceptable result being obtained in the six cases studied in this series. The one good result was in a seven-year-old colored male. He had sustained severe trauma when struck by an automobile and had intra-abdominal injuries in addition to the fractured hip. The femoral head was not dislocated from the acetabulum. He was treated by closed reduction and insertion of two Knowles pins. Six weeks later the pins were removed, as they were observed to be distracting the fragments. A Whitman cast was applied and a good result ensued (Case 5, Figs. 1-A to 1-F). The causes of the poor results in the remaining five cases were avascular necrosis in four and postoperative wound infection with absorption of the femoral head

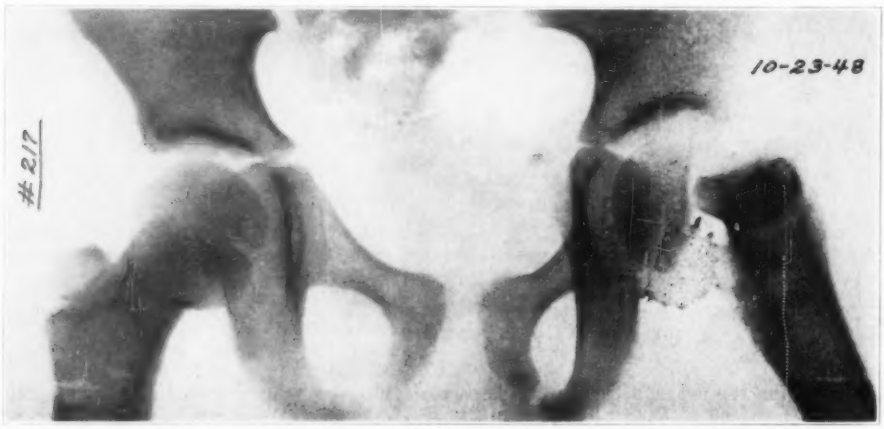

FIG. 1-A

October 23, 1948. Case 5, colored male seven years old. He sustained a transepiphyseal fracture of the hip without dislocation of the femoral head.

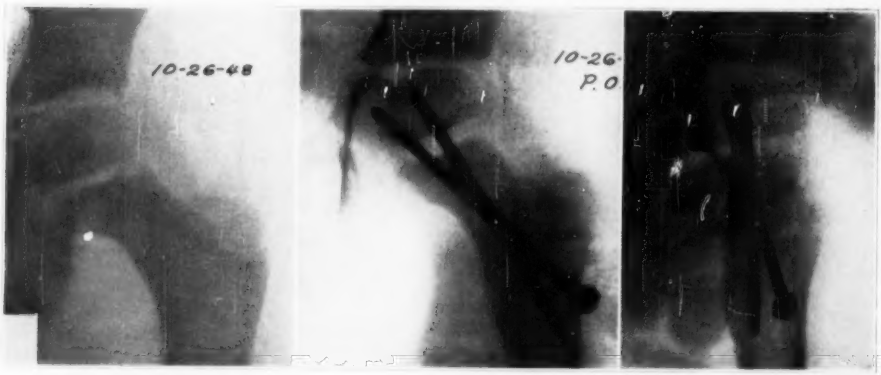

FIG. 1-B FIG. 1-C

Fig. 1-B: Roentgenograms made immediately after reduction, October 26, 1948.
Fig. 1-C: The Knowles pins were improperly inserted and held the fragments apart.

FIG. 1-D FIG. 1-E

Fig. 1-D: December 6, 1948. Roentgenogram made after removal of Knowles pins, six weeks after operation.
Fig. 1-E: March 17, 1949. Roentgenograms made five months after operation. The epiphysis had fused and the fracture had healed.

FIG. 1-F

October 1, 1952. Roentgenograms made four years after operation revealed a viable head, normal joint space, and a somewhat short femoral neck. This patient had a good result.

TABLE I

TYPE I: TRANSEPIPHYSEAL FRACTURES OF THE HIP

Case No. Year	Femoral Head Dislocated	Definitive Treatment	Immediate Result	Union	Coxa Vara	Avascular Necrosis	Result and Comment
1. 1930	Yes	Open reduction and Whitman cast 8 weeks after injury. No internal fixation.	Good	No			Poor. Wound infection; reduction lost, femoral head absorbed.
2. 1932	Yes	Open reduction and Whitman cast 3 weeks after injury. No internal fixation.	Good	Yes	No	Yes	Poor. Avascular necrosis.
3. 1940	Yes	Closed manipulation and Whitman cast.	Poor. Head not replaced.			Yes	Poor. Avascular necrosis.
4. 1944	Yes	Open reduction and Whitman cast 12 days after injury. No internal fixation. Fragments slipped in cast.	Good	Yes	Yes	Yes	Poor. Avascular necrosis and coxa vara.
5. 1948	No	Skin traction for 3 weeks, then open reduction and 2 Knowles pins.	Poor. Pins distracted the fragments; removed after six weeks and Whitman cast applied.	No	No	No	Good. Patient had 1.5 centimeters overgrowth of affected femur four years later at age of nine.
6. 1951	Yes	Open reduction 4 days after injury; 1 Knowles pin.	Good	Yes	No	Yes	Fair. Non-weight-bearing for 19 months; moderate residual flattening of femoral head.

TABLE II

TYPE II: TRANSCERVICAL FRACTURES OF THE HIP

Case No. Date	Definitive Treatment	Immediate Result	Union	Coxa Vara	Avascular Necrosis	Result and Comment
7. 1930	Closed manipulation and Whitman cast.	Good early result but fragments slipped in cast.	Delayed	Yes, 80 degrees	Yes, at 12 months	Poor. Avascular necrosis.
8. 1939	Open reduction with Smith-Petersen nail 6 weeks after injury.	Good	Yes, at 2 months	No	No	Excellent. Twelve-year follow-up.
9. 1944	Closed reduction, 2 Knowles pins.	Good	Yes, at 4 months	No	No	Good. Pins arrested epiphyseal growth.
10. 1948	Closed reduction, 3 Knowles pins.	Good	Yes, at 2 months	No	No	Excellent. Four-year follow-up.
11. 1949	Closed reduction, 3 Knowles pins.	Good	Yes, at 3 months	No	No	Excellent. Three-year follow-up.
12. 1951	Closed reduction, 3 Knowles pins.	Good	Yes, at 4½ months	No	No	Excellent result.
13. 1951	Closed reduction 3 weeks after injury, 4 Knowles pins.	Good	No	No	Not at 15 months	Blount osteotomy at 10 months for non-union. Union progressing and head viable 5 months later.
14. 1951	Closed reduction, 3 Knowles pins.	Good	Yes	No	Yes, at 11 months	Poor. Avascular necrosis.
15. 1952	Closed reduction, 3 Knowles pins.	Good	Yes, at 3 months	No	Too early	Good early result. Prompt union of Pauwels Type III neck fracture.
16. 1952	Closed reduction, 3 Knowles pins.	Good	Yes, at 4 months	No	Too early	Good early result. Pauwels Type III.
17. 1952	Closed reduction, 3 Knowles pins.	Good	Yes, at 3 months	No	Too early	Good early result.

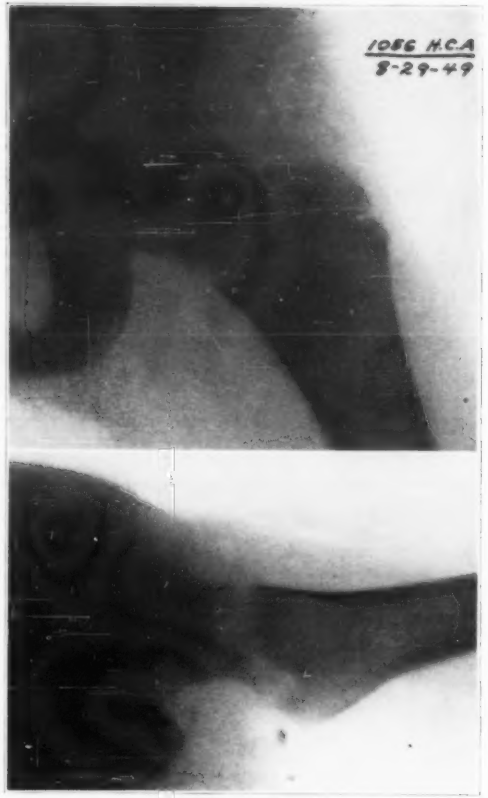

FIG. 2-A

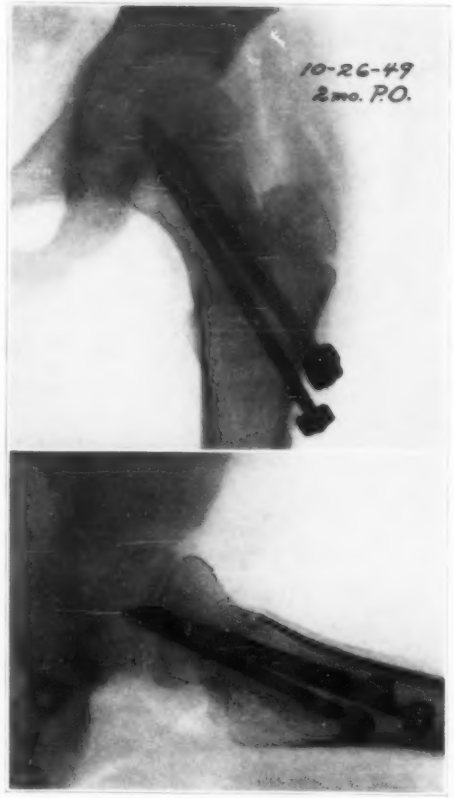

FIG. 2-B

FIG. 2-C

Fig. 2-A: August 29, 1949. Case 11. Roentgenograms made after reduction. The patient was a six-year-old girl with a transcervical fracture.
Fig. 2-B: October 26, 1949. Two months after reduction the fracture had healed.
Fig. 2-C: July 21, 1950. Roentgenograms made eleven months after operation.

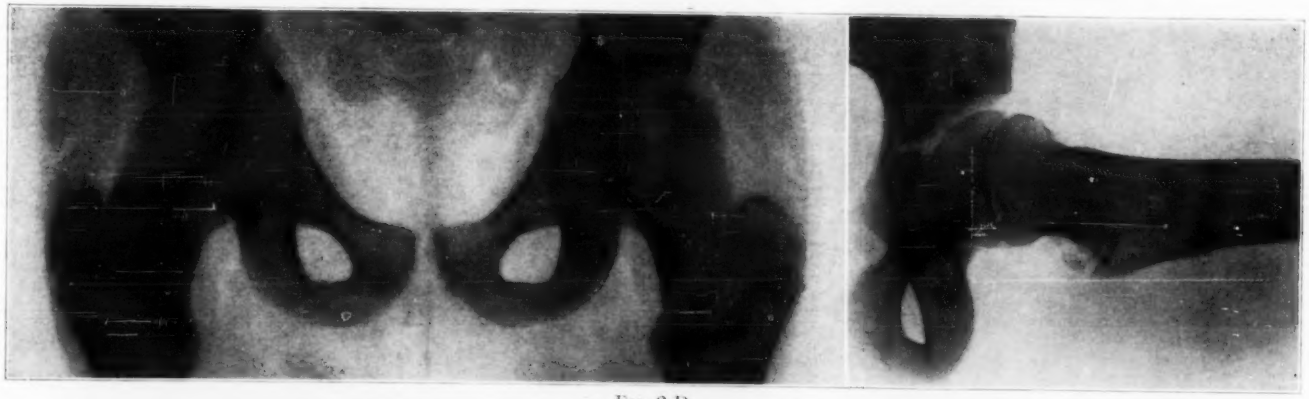

FIG. 2-D

FIG. 2-E

Fig. 2-D: April 25, 1951. Roentgenograms made eighteen months after injury.
Fig. 2-E: May 28, 1952. Two and one-half years after injury the hip was essentially normal and the patient had no complaints.

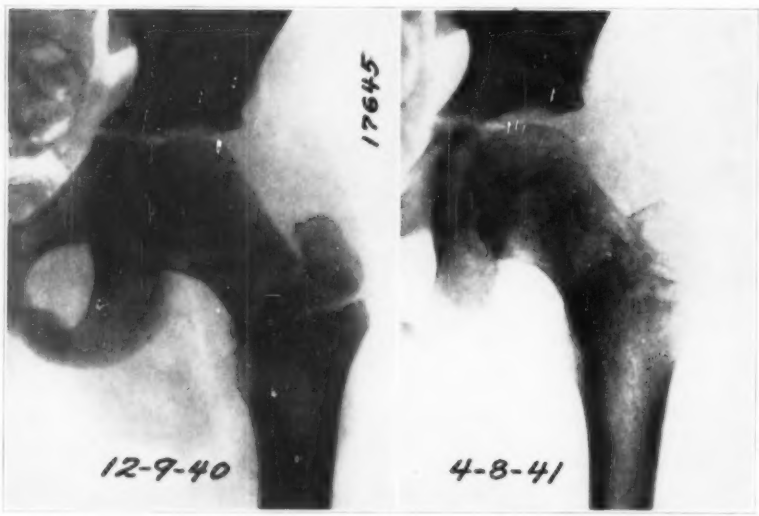

FIG. 3-A FIG. 3-B

Fig. 3-A: December 9, 1940. Case 23. The roentgenogram showed an intertrochanteric fracture in a boy aged ten.

Fig. 3-B: April 8, 1941. Four months after injury the fracture had healed in good position. The patient had been in a Hoke-Martin cast for ten weeks.

in one. The latter patient was treated prior to the chemotherapeutic and antibiotic era. The ages in this group ranged from two to fifteen years. All of these patients had sustained severe trauma and most of them had had fractures of other bones. The poor prognosis in patients in this category is based on the exceedingly high incidence of avascular necrosis.

Type II: Transcervical Fractures

Eleven of the twenty-four patients were in this category (Table II) and the results

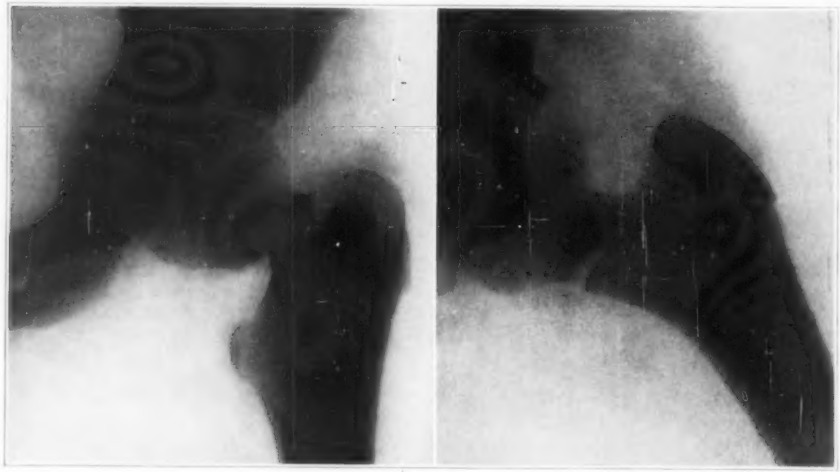

FIG. 4-A

July 31, 1930. Case 4. The roentgenograms showed an excellent reduction of a transcervical fracture in an eleven-year-old girl.

FIG. 4-B

FIG. 4-C

Fig. 4-B: September 25, 1930. Roentgenogram made two months after reduction showed that the fragments had slipped while the patient was in a Whitman cast.

Fig. 4-C: March 23, 1931. A roentgenogram made eight months after reduction revealed further displacement. Union had taken place in the varus position and there was avascular necrosis of the head.

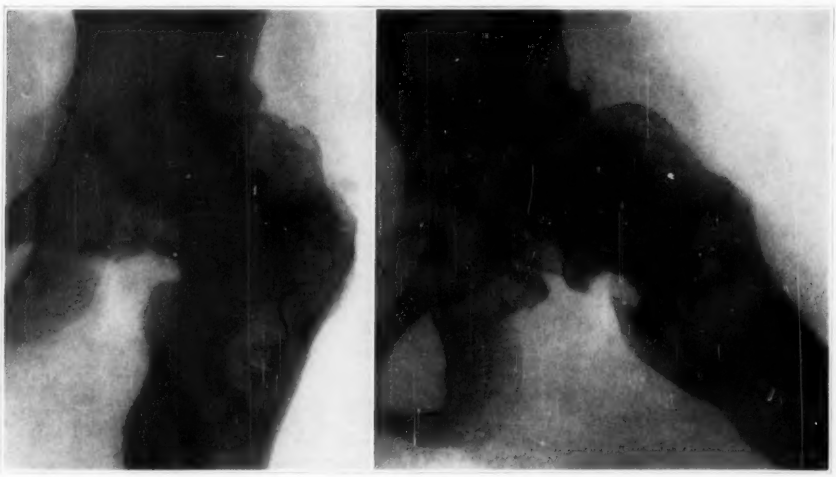

FIG. 4-D

November 10, 1943. Roentgenograms made thirteen years after reduction. The patient had had two osteotomies to correct the varus position. She later had an arthrodesis for a traumatic arthritis secondary to the avascular necrosis.

in this group of patients are definitely better than those reported by other authors. Ten of the eleven patients have been followed for more than six months; of these one had delayed union (five to six months) and one had non-union (Case 13, Figs. 5-A to 5-F). This case will be discussed in detail. Solid bony union occurred within two to four and one-half months in nine of the eleven cases.

Eight of the eleven patients have been followed for more than one year, and in two of these avascular necrosis of the femoral head developed. One of these (Case 7, Figs. 7-A to 7-E) was treated by the Whitman method; the fragments slipped in the cast, union

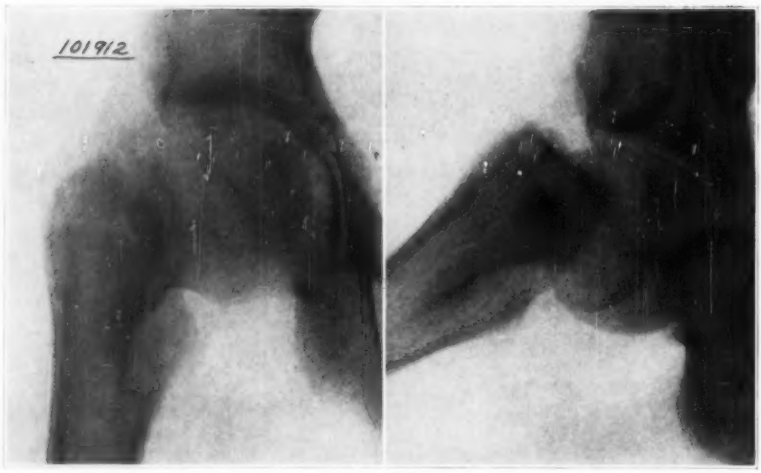

FIG. 5-A

October 20, 1951. Case 13. Roentgenogram made three weeks after injury, showing a transcervical fracture in a boy aged thirteen.

FIG. 5-B

FIG. 5-B

October 29, 1951. The roentgenograms showed an excellent reduction and proper placement of four Knowles pins.

occurred in the varus position, and avascular necrosis followed. The other (Case 14) was treated by closed reduction and insertion of three Knowles pins.

Only one transcervical fracture (Case 7, Figs. 7-A to 7-E) was complicated by malunion in the coxa vara position, mentioned above.

Type III: Cervicotrochanteric Fractures

There were only five cases in this group (Table III), despite the fact that most authors consider this the most common site of hip fracture in children. In all five cases bony union in a satisfactory position was obtained in two or three months (Figs. 6-A to 6-D). In two of these cases there was no significant separation of the fragments and the fracture healed uneventfully on the Whitman regimen. Only two of the patients have been followed for more than twelve months and avascular necrosis of the femoral head has not developed in either of them.

Type IV: Intertrochanteric Fractures

Intertrochanteric fractures of the hip in children are rare compared with their inci-

FIG. 5-C

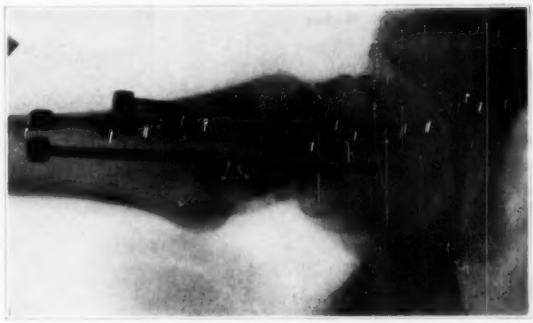

FIG. 5-C

February 8, 1952. Three and one-half months after reduction there was absorption of the neck and extrusion of the pins.

FIG. 5-D

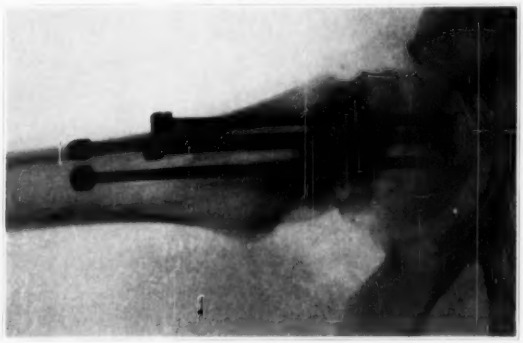

FIG. 5-D

May 9, 1952

dence in adults, only two cases (8 per cent.) being encountered in this series (Table IV). In adults, by contrast, intertrochanteric fractures constitute between 50 and 55 per cent. of all fractures of the upper portion of the femur. The anatomical, physiological, and therapeutic problems which are encountered in Delbet's fractures of Types I, II, and III were not encountered in this group. They are included in this discussion for completeness and because of their rarity. Both patients in this group obtained excellent results after treatment by traction. One patient (Case 23, Figs. 3-A and 3-B) was treated by a Hoke-Martin traction cast; the other (Case 24) had multiple compound fractures and was treated by skeletal traction. No complications were encountered in these two cases.

DISCUSSION

Bony union of the fracture within six months after institution of treatment was obtained in twenty-one of the twenty-four cases. In the cases in which union occurred it was unmistakably demonstrable on roentgenograms between two and three months after operation in sixteen cases, four months after operation in four cases, and six months after operation in one. In three instances the fracture failed to unite. Two of these were Type I

FIG. 5-E

FIG. 5-E

July 3, 1952

Figs. 5-D and 5-E: At six months and eight months after reduction, non-union is evident.

FIG. 5-F

December 5, 1952. Roentgenograms made five months after a Blount osteotomy, showing almost solid union.

Apposition of the fragments is more difficult to maintain if four pins are used as absorption of fracture surfaces occurs.

FIG. 5-F

(transepiphyseal) fractures with dislocation of the femoral head from the acetabulum. In one of these (Case 1) the fracture had never been reduced and in the other (Case 3) wound infection and pyarthrosis developed with absorption of the femoral head. The remaining case of non-union encountered in this series was in Case 13 (Figs. 5-A to 5-F). This patient had sustained a transcervical fracture three weeks prior to his examination. He was treated by a closed reduction and insertion of four Knowles pins. Despite an excellent reduction and almost perfect placement of the pins, the fragments did not appose, as the femoral neck was absorbed and a definite state of non-union developed. Ten months after injury a Blount-type osteotomy of the hip was done; union was almost completely solid five months after the second operation. The femoral head has remained viable.

Internal fixation of fractures of the neck of the femur in adults is a generally accepted surgical procedure. It has not only diminished the morbidity and mortality rates in adults, but has likewise significantly lowered the incidence of non-union. The authors contend that its routine use in fractures of Delbet's Types I, II, and III will provide similar benefits in children.

FIG. 6-A

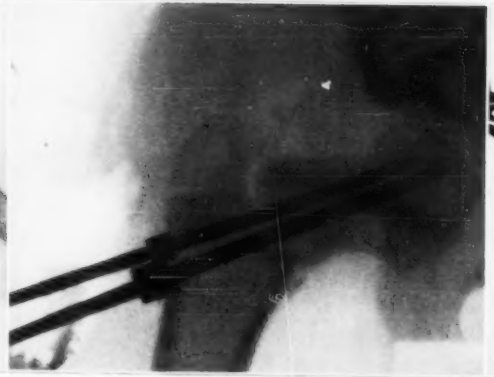

FIG. 6-B

FIG. 6-C

FIG. 6-D

Fig. 6-A: August 30, 1952. Case 18. The roentgenogram shows a cervicotrochanteric fracture in a girl aged eight.
Fig. 6-B: September 1, 1952. Some varus remained after reduction.
Fig. 6-C: October 24, 1952. Seven weeks after reduction union was almost solid.
Fig. 6-D: January 17, 1953. At four and one-half months after operation the fracture had healed. There was no change in the varus position, but the hip was asymptomatic and the early result was good.

TABLE III

TYPE III: CERVICOTROCHANTERIC FRACTURES OF THE HIP

Case No. Date	Definitive Treatment	Immediate Result	Union	Coxa Vara	Avascular Necrosis	Result and Comment
18. 1931	Closed reduction and Whitman cast.	Good	Yes	No	No	Excellent. Fourteen-year follow-up. Some overgrowth of femoral neck.
19. 1935	Closed reduction and Hoke-Martin traction cast for $2\frac{1}{2}$ months.	Good	Yes, at $2\frac{1}{2}$ months	No	Too early	Excellent; short follow-up.
20. 1949	Whitman cast.	Good	Yes, at $2\frac{1}{2}$ months	No	Too early	Excellent. Short follow-up. Fragments not displaced.
21. 1950	Whitman cast.	Good	Yes	No	No	Excellent. Fragments not displaced.
22. 1952	Closed reduction, 3 Knowles pins.	Good	Yes, at 2 months	No	Too early	Excellent. Short follow-up.

TABLE IV

TYPE IV: INTERTROCHANTERIC FRACTURES OF THE HIP

Case No. Date	Definitive Treatment	Immediate Result	Union	Coxa Vara	Avascular Necrosis	Result and Comment
23. 1940	Closed reduction. Hoke-Martin traction cast for $2\frac{1}{2}$ months.	Good	Yes, at $2\frac{1}{2}$ months	No	Too early	Excellent. Short follow-up (6 months).
24. 1949	Skeletal traction.	Good	Yes, at 4 months	No	No	Excellent. Multiple compound fractures. Three-year follow-up.

FIG. 7-A

FIG. 7-B

FIG. 7-C

Fig. 7-A: May 6, 1944. Case 7. The roentgenogram showed a transepiphyseal fracture with dislocation of the head.
Fig. 7-B: July 7, 1944. Two months after injury the femoral head had remained viable.
Fig. 7-C: March 1, 1945. Roentgenogram made eight months after operation.

FIG. 7-D

FIG. 7-E

Fig. 7-D: August 17, 1949. Roentgenogram made five years after operation.
Fig. 7-E: November 23, 1952. Eight years after operation there was a poor result.

FIG. 8-A

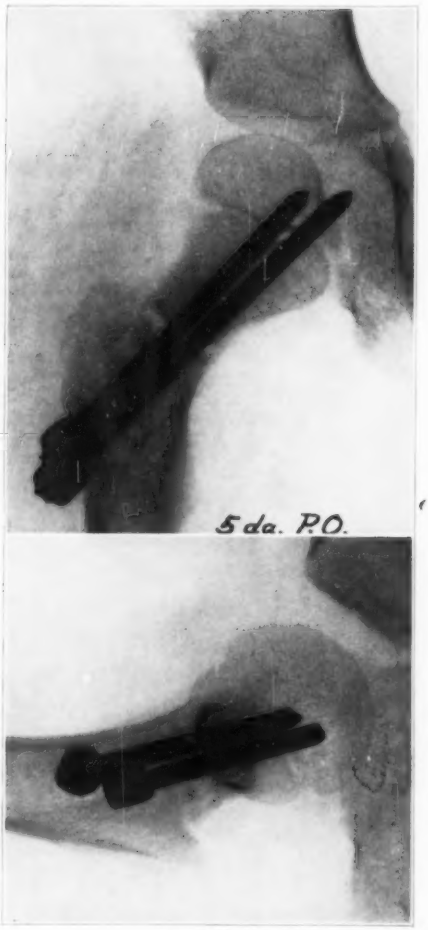

FIG. 8-B

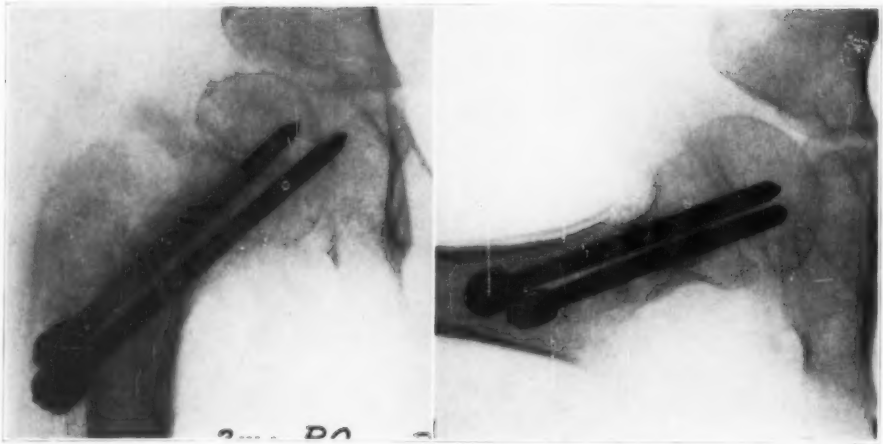

FIG. 8-C

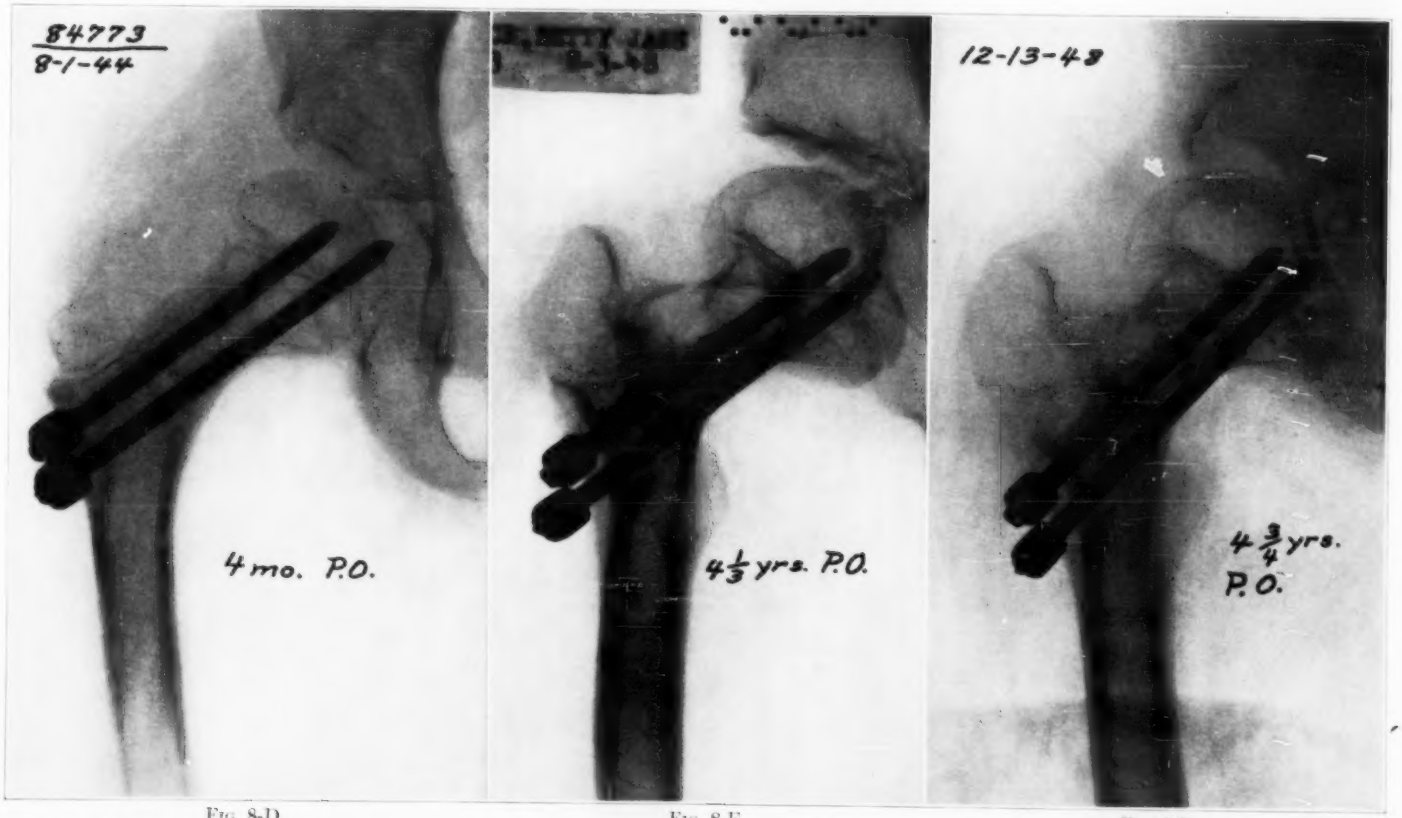

FIG. 8-D

FIG. 8-E

FIG. 8-F

Fig. 8-A: March 23, 1944. Case 9. Roentgenograms showed a transcervical fracture in a nine-year-old girl. The extremity had been paralyzed by poliomyelitis since infancy.

(*Continued on page 884*)

(*Continued from page 883*)

Fig. 8-B: March 29, 1944. Roentgenograms made five days after reduction.

Fig. 8-C: May 29, 1944. Two months after injury there was almost solid union.

Fig. 8-D: August 1, 1944. Four months after reduction union was solid.

Fig. 8-E: August 3, 1948. Result four years and four months after reduction. The patient had not returned for removal of pins.

Fig. 8-F: December 13, 1948. Longitudinal growth of the femoral neck had been retarded. Circumferential growth of the head apparently had not been retarded.

The principle of the triflanged nail, although eminently satisfactory in adults, is less desirable in children because the density of the femoral neck and head presents certain mechanical problems. In adults, and especially in the aged, the Smith-Petersen nail can be inserted in the medullary canal of the femoral neck with ease and, as the cutting end of the nail enters the finer trabeculations of the femoral head, the fracture line is impacted. The insertion of a Smith-Petersen nail through the firm cancellous bone of a child's fractured femoral neck, however, is accompanied by a definite springiness which actually permits the fracture line to be distracted as the nail is driven forcefully into the femoral head. Moreover, on cross-section the cancellous portion of the femoral neck is found to be very small and, unless the Smith-Petersen nail is exactly centered in the medullary canal, it will be found to impinge on one or more of the cortices of the neck.

Occasionally it is impossible to pass an ordinary Smith-Petersen nail through the femoral neck without impinging on the cortex at some point, because of the combination of the above factors and of the normal curve of the femoral neck in a child. The authors have encountered one case in which distraction occurred as the nail entered the femoral head; the nail had to be removed before the fragments could be apposed. This patient was treated in another hospital several years ago; unfortunately his roentgenograms have been destroyed and his clinical record has been lost, and for these reasons this patient is not included in the present series.

In our experience the fracture fragments can be immobilized just as securely by two or three Knowles pins, and insertion is accomplished with less surgical trauma. Certain precautions must be observed, however, in the use of Knowles pins for these fractures. First of all, two or three pins should be parallel to each other, or nearly so, as they cross the fracture line. If the pins are crossed so that their shadow makes an *X*, they will have a tendency to hold the fracture line open, as is demonstrated in Figure 1-C. If three pins are used, which has been found ideal in the authors' experience, they should be inserted parallel to each other and their placement should be such that their bases form an equilateral triangle.

Of the twenty-one fractures which united, two healed in the coxa vara position and seventeen healed in satisfactory alignment. Both of the patients with varus had been treated by the Whitman method. This complication is caused either by inadequate reduction or by loss of reduction during the healing stage. If fractures of the femoral neck or of the cervicotrochanteric region are treated by gentle closed reduction on an orthopaedic table, with use of two-plane roentgenographic control, and two or three Knowles pins are inserted, the incidence of this complication should be kept at a minimum.

Avascular necrosis of the capital femoral epiphysis is a serious complication of these fractures according to all published reports. The authors agree with Green, Badgley and his associates, Martin, Boyd and George, and others [4] that this complication is caused by interruption of the blood supply to the femoral head.

As was demonstrated by Wolcott and substantiated and amplified by Tucker, the only significant arterial supply to the ossification center of the growing femoral head is by three main vessels: the posterosuperior and postero-inferior retinacular branches of the medial femoral circumflex artery and the smaller, less constant, and less important anterior retinacular branch of the lateral femoral circumflex artery. These arterial branches penetrate the capsule of the hip joint at or near the distal attachment of the capsule to the femur and course proximally in a loose areolar bed beneath folds of syno-

vial membrane, sending out small branches to the femoral neck which anastomose with the nutrient artery. They enter the epiphysis at or immediately proximal to the epiphyseal plate and course directly to the ossification center. These vessels are fixed directly to the bone proximally at the epiphyseal line and distally, at the point where they enter the capsule, they are also fixed by angulation. Between these two points, and especially at the mid-cervical level, these vessels are quite mobile and therefore less subject to injury.

As regards fractures of the hip in children, then, it is apparent that the incidence of avascular necrosis of the femoral head depends on several factors. The location of the fracture and the degree of separation of the fragments are of greatest significance. Also important, from a theoretical standpoint at least, are: the amount of secondary mobilization of the fragments (that is, repeated manipulations), the accuracy of reduction, the maintenance of reduction, and the promptness of bony union. Internal fixation of fractures of the femoral neck provides immediate immobilization, which is continued until the fragments have united. The immobilization is much more secure than that obtained by the Whitman cast. Certainly an avascular fragment can be more rapidly revascularized by "creeping substitution" if the fragments are securely held by internal fixation.

Of the seventeen patients in this group followed for more than one year, avascular necrosis occurred in six instances. The six patients with fracture through the epiphyseal plate (the only such group the authors have been able to locate in the literature), had worse results than any group of patients previously reported, regardless of treatment. All five of those whose femoral head was dislocated from the acetabulum had poor results; infection developed in one and avascular necrosis in four. The one patient without dislocation of the femoral head did not exhibit avascular necrosis. Of Type II (transcervical) fractures avascular necrosis developed in two of the eight patients followed for more than one year. In this small series of cases this figure is comparable to Boyd and George's incidence of avascular necrosis in 33.6 per cent. of fractures of the femoral neck in adults. Actually from theoretical considerations one would expect a higher incidence in children than in adults with similar fractures, since the anastomosis within the femoral head is probably better in adults than in children. Of Type III, or cervicotrochanteric, fractures, only two patients were followed for more than one year and neither exhibited avascular necrosis. The anastomosis about the distal portion of the hip-joint capsule is quite good; this apparently accounts for the diminished incidence of avascular necrosis in fractures in this location. The rare intertrochanteric fracture of the femur should not be associated with any significant incidence of avascular necrosis. None was encountered in the two cases in this series.

In those patients in this series in whom avascular necrosis developed, this complication was unmistakably apparent on roentgenograms made between ten and twelve months after operation in all cases. For this reason, patients followed for less than twelve months were omitted from the study of avascular necrosis and all patients who were stated to be free of this complication were followed for a minimum of twelve months.

Close study of these cases fails to reveal any consistent deviation from the normal growth pattern of the affected extremity. Overgrowth of the femoral neck was seen in Cases 5 and 8. Another patient (Case 9, Figs. 8-A to 8-E), who did not return for removal of the Knowles pins, demonstrated that, although the epiphysis had not yet fused, the longitudinal growth of the femoral neck was significantly retarded by the Knowles pins, while the circumferential growth of the femoral head did not seem to be significantly retarded. For this reason, Knowles pins should be removed when bony union occurs. We have not observed any cases in which permanent epiphyseal arrest occurred as the result of transfixion by Knowles pins.

Five secondary operations were performed on patients studied in this report, exclusive of operations for removal of the internal fixation devices. One patient had a Blount osteotomy for non-union. Another had two intertrochanteric osteotomies to correct coxa vara

deformity following the Whitman treatment. One had a mold arthroplasty, and one an arthrodesis for traumatic arthritis secondary to avascular necrosis of the femoral head.

SUMMARY

The following are the authors' indications for the treatment of fractures of the hip in children, based on observations in this group of cases and on theoretical considerations:

Type I: Transepiphyseal fractures:

A. Without dislocation of femoral head: gentle closed manipulation and insertion of two or three parallel Knowles pins. The capsule of the hip joint should not be opened.

B. With dislocation of femoral head: open reduction, internal fixation with two or three Knowles pins, and prolonged non-weight-bearing.

Type II: Transcervical: gentle closed manipulative reduction and insertion of two or three Knowles pins. The capsule of the hip joint should not be opened.

Type III: Cervicotrochanteric:

A. If fragments are separated: gentle closed manipulative reduction and insertion of two or three Knowles pins.

B. If fragments are not separated: a Hoke-Martin traction cast, or a Whitman abduction cast.

Type IV: Intertrochanteric: gentle closed manipulative reduction and application of a Hoke-Martin traction cast.

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DISCUSSION

Dr. William T. Green, M.D., Boston, Massachusetts: Since I can find little with which to disagree I should like to complement the authors' presentation with some of our observations.

The first of these has to do with the so-called transepiphyseal fracture or what we call a metaphyseal fracture, since the fracture line goes through the metaphysis. In a small, incomplete series of eight cases at the Children's Hospital, Boston, unselected except by chance, three were in this category. They followed an entirely different pattern from that shown by the authors. The femoral heads were only moderately displaced. The trauma was much less severe. They were treated by gentle closed reduction or by traction and by plaster immobilization. In none was there aseptic necrosis. The difference in the course of the two groups of cases

arose from the difference in the degree of original trauma and of vascular injury. Dr. Ingram's cases represented the result of severe trauma; ours that of a lesser degree of injury.

Another type of fracture in this area with which we have had experience and which was not discussed by the authors is that of metaphyseal fracture occurring at birth in which the epiphyses both of the head of the femur and of the trochanter are displaced. Since there is no ossification in the epiphysis at this time, this fracture may be mistaken in the roentgenogram for a dislocated hip. The excessive calcification which appears about the area ten days or so after birth is diagnostic. Ordinarily no treatment is necessary.

There were no instances of aseptic necrosis in our eight cases except for one occurring after a fracture of the trochanter which was perfectly replaced and healed rapidly. Six months later there were symptoms and roentgenograms revealed aseptic necrosis of the head. A secondary plastic procedure was performed on the head of the femur to give a good functional result.

It is well to remember that the location where the vascular supply is in closest relation to bone and where it is most immobile is in the area of the base of the neck and the epiphyseal plate. The real problem in all these cases is aseptic necrosis arising from vascular injury. Ordinarily, this arises from the original trauma. However, we must be sure our treatment does not add to the trauma. All attempted closed reductions must be most gentle and, unless reduction is accomplished very easily, open reduction should be performed, in order to preserve the blood supply carefully.

Finally, I would like to comment regarding skeletal fixation which transfixes the epiphyseal cartilaginous plate. We have found experimentally that, if a screw of wood type firmly holds the head, growth may be stopped by compression of the epiphysis. On the other hand, a nail or pin of a reasonable size will not do this.

I would commend Dr. Ingram for his shift from four pins to three or even two. Perhaps the shift should be to one or two pins or to nails of small caliber in most fractures, with accessory protection as needed. Ordinarily, if these fractures are treated early, they heal rapidly if they are going to unite. In fractures of the distal portion of the neck, for example, we have on occasion used a single small-calibered flanged nail which is stopped short of the epiphysis. This is possible because of the cancellous nature of the proximal portion of the neck.

DR. RUSSELL H. SULLIVAN, BROOKLINE, MASSACHUSETTS: In the patients studied by us who were admitted to Boston City Hospital from 1934 through 1952, we considered only intracapsular fractures. We did not include any cases of traumatic slipping of the epiphysis nor did we consider any fractures at the intertrochanteric level. In all our cases the fracture occurred within the capsule and within the limits of the femoral neck. The series at the Campbell Clinic apparently began in 1930, whereas our series dates back only to 1934. Our total number of cases was twelve, whereas the speaker's was twenty-four, but considering that an additional four-year period of time was included in the Memphis series and that in eight of the authors' twenty-four cases the fracture sites were at levels which we did not consider at all, it is obvious that the frequency with which this lesion is encountered is about the same in both clinics.

Our age incidence was only a little higher and our proportion of males to females was a little higher.

All of our cases except those in which there was definitely pathological bone occurred after severe trauma and I think that was also true in the series reported by Dr. Ingram.

I agree with the speaker's view of the difficulties in the technique of nailing in these cases. The target is smaller in the neck of a child's femur. The cancellous bone is very firm and springy and the fragments tend to separate as the nail is driven across the fracture line.

I also agree that a cast without internal fixation of some kind is not very safe.

I am sure that the authors' results have been better than ours. This may well be due to the fact that they have used multiple pinning rather than a Smith-Petersen type of nail in their internal fixation treatment.

Our conclusions were that the probable reason for failure in securing union was based mostly on the circulatory pattern of this region in children. Wolcott's studies [a] showed that the ligamentum teres blood vessel is not patent until approximately the age of thirteen.

Cheynel, of Paris, in 1947 performed autopsies upon the hip joints in both children and adults [b] and it would seem from his work that the capsular vessels are hardly adequate for circulation to the head of the femur in a child even under normal circumstances. Therefore, when trauma occurs and the femoral head is damaged, it is almost inevitable that the blood supply will prove inadequate.

As regards treatment we have concluded, as a result of our experiences, that the safest and best way to treat a fracture in the true neck of the femur in a child is by immediate open reduction, drilling with a fairly large-sized drill into the neck under roentgenographic visualization, and insertion of a graft of cancellous bone. We did this in one case which occurred in 1951 and the x-rays showed that the fracture healed with solid union without any difficulty.

I am sure the authors have contributed considerably to our knowledge of this subject and I shall be anxious to try multiple pinning, although I am convinced that use of an intramedullary graft is an excellent method of handling this type of case.

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OSTEOID OSTEOMA IN THE HAND*

BY ROBERT E. CARROLL, M.D., NEW YORK, N. Y.

Present knowledge of the lesion in the bone known as osteoid osteoma arises from the work of H. L. Jaffe [8]. In 1935, he crystallized experience and thought to describe the clinical and pathological data of this benign osteoblastic tumor. Since then, the literature has contained reports of single cases and reviews of reported material [3,5,17,21]. It is generally accepted that the tibia and femur are the most common sites for this lesion. The bone structure of the body's most mobile unit, the hand, has not been a frequent location. Tumors of the hand, in general, are not common. It seemed profitable to direct attention to the role of osteoid osteoma in the hand. Six new cases are reported to amplify the clinical picture.

This type of tumor had been described in the literature prior to Jaffe's paper. A different theory of etiology was presented with each case. In these few early cases, it is of interest to note that the lesion was frequently reported to be located in the hand. Perhaps the earliest known case of osteoid osteoma was found in the proximal phalanx of the left ring finger. This was described by Heine in 1927. The digit had been amputated, as tuberculosis had been suspected. The best pathological picture of all the early cases was described by Bergstrand in 1930. In his two patients, the lesion of one was located in the proximal phalanx of the middle finger. This digit had been amputated as the lesion was thought to be osteogenic sarcoma. In the same year, 1930, Hitzrot described a lesion of the left carpal scaphoid which had a clinical picture and pathological findings suggestive of osteoid osteoma. In 1932, Jaffe and Mayer [11] described a tumor of the metacarpal containing large amounts of osteoblastic osteoid tissue. Raspall and Llort found an unusual lesion of the carpal navicular (scaphoid), which closely resembled an osteoid osteoma in the clinical and pathological findings. This was reported in 1935. During the same year, Zanoli described a lesion of the capitate which must be accepted as an osteoid osteoma. These cases were described under various diagnoses before the excellent work of Jaffe in 1935 clearly established osteoid osteoma as a distinct entity.

THE CLINICAL PICTURE

The history of all cases of osteoid osteoma is essentially the same. As with most tumors, there is a tendency on the part of the patient to link osteoid osteoma to trauma. No specific connection can be proved. The terminal phalanx is the most frequently traumatized area of the hand, yet we can find only two cases of osteoid osteoma occurring in this phalanx. From the location of the tumor in the bones of the hand, it would be hard to believe that trauma was the initiating factor.

The persistence of pain is a common finding. The pain is of an aching nature; it is readily borne during the day, but greatly disturbs the rest at night. No pangs of acute pain urge the patient to seek aid. Strangely enough the pain is commonly relieved by a single dose of aspirin. No physiological reason has yet been ascribed to this phenomenon. The pain has usually been present for several months; it has not been sufficient to limit the use of the hand.

Swelling of the affected member is also commonly found. There is slow but marked swelling of the metacarpal or phalangeal area, or of the whole finger, which is easily noticed on examination. The swelling may have been present for several months; in the early

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phase of development, it may be barely discernible. Swelling in the area of the metacarpal does not impede the motion of the digit; but a swelling of the whole finger may limit motion.

CASE 1. K. D., a twelve-year-old girl, noticed some mild pain in the area of the metacarpophalangeal joint of the hand. Slight swelling was also found in this area. Over the course of the next twelve months, the pain became more frequent; it could easily and quickly be relieved by aspirin. Swelling of the metacarpal became more noticeable.

Examination of the right hand revealed a marked swelling in the second metacarpal area. The range of motion in the metacarpophalangeal joint was normal and painless. Pressure to the distal shaft of the metacarpal was quite painful. Roentgenograms demonstrated diffuse sclerosis of the entire metacarpal shaft with a central nidus in the distal portion of the diaphysis (Fig. 1).

After excision of the reddish-brown material of the nidus, the pain vanished. During the three years that this patient has been followed, the swelling has been found to decrease slowly, and sclerosis of bone has persisted in the metacarpal shaft.

CASE 2. W. J., a thirteen-year-old boy, had a central nidus in the mid-shaft of the second metacarpal of the right hand. A history of pain and swelling of four months' duration was present. Relief was obtained from surgery.

CASE 3. E. W., a woman, twenty-seven years old, complained of aching pain in the second metacarpal of the left hand, present for a period of twelve months. A central nidus was found in the distal third of a sclerotic metacarpal shaft. Excision of the nidus produced immediate relief.

In the examination, pressure over the area of the tumor nidus may elicit a painful response. This is not the case when other areas of the swollen hand are pressed. On a preoperative examination, this factor is helpful in correlating the roentgenographic location with the planned surgical approach.

The patients usually are young—in the second and third decades of life. They are fairly evenly distributed between male and female. No history of antecedent infection in the affected area or in the body has been found. The general health is good.

THE ROENTGENOGRAPHIC APPEARANCE

This is by far the most pertinent factor in the diagnosis [9]. There is generally diffuse sclerosis of the involved bone. One may see the central nidus appearing as an area of lucency. This area usually attains the size of a pea. In the small bones of the hand, however, the nidus may appear in a different form, presenting a granular opacity. Surrounding this is a perimeter of radiolucency, separating the nidus from the surrounding sclerotic bone. In the literature, this form of nidus has been called a "ring sequestrum". A radiolucent nidus may change with time so as to present a picture of central isolated opacity. The roentgenographic location is confirmed by surgery.

There are three locations for the nidus of osteoid osteoma. Location of the nidus in the medullary spongy bone is not uncommon. It produces sclerosis of the entire cortex and shaft; the area can usually be spotted in the roentgenograms.

About as common is the case of the nidus located in the cortex of the bone. Dense layers of sclerotic bone enlarge the shaft throughout the area. The medullary cavity and opposing cortex can be free of sclerotic change. The small lucent nidus can usually be found in the center of the sclerotic spindle. Locating the nidus may often be extremely difficult.

CASE 4. M. R., a man twenty-two years old, noted some pain and swelling in the vicinity of the proximal phalanx of his right index finger. These symptoms had been present for a month before he sought advice. Roentgenograms revealed some sclerosis and thickening of the cortex in the proximal phalanx (Fig. 2). During the next eleven months, pain and swelling increased. The films showed increase in the cortical thickening with location of a cortical nidus within the sclerotic mass of bone. Removal of the nidus by surgery gave complete relief of pain. (Case included by courtesy of Dr. Bradley L. Coley.)

The most unusual form of osteoid osteoma is one in a periosteal location, where the nidus elevates the periosteum. There may be a thin wafer of osseous tissue covering it. The adjacent cortex may show little or no sclerosis or it may become quite sclerotic. Only two cases of this type have been reported [10]; both occurred in the area of the proximal

phalanx. In the treatment of this type of tumor, the periosteal location of osteoid osteoma must be recognized, and x-rays of the area must include precise anteroposterior and lateral views. The author has encountered one similar case which occurred in the proximal phalanx of the hand (Fig. 3). To aid in fully appreciating the problem, this case is presented.

CASE 5. A. A., a man twenty-three years old, complained of painful swelling of the right index finger, which had been present for approximately two months. The patient remembered that his hand had been caught and pinched between two boxes just about the time he first noticed the pain and swelling. Roentgenograms revealed a lytic area in the distal portion of the proximal phalanx of the right index finger. Diffuse sclerosis of the phalanx was present. This area had been investigated by surgical biopsy on three separate occasions. The report in each case was "fragments of necrotic bone". The dull aching pain persisted.

When first examined by the author, ten months after the onset, the patient had diffuse swelling of the index finger. A healed scar was present over the lateral aspect of the proximal phalanx. Range of motion in the digital joints was quite limited. Pressure on the volar aspect of the proximal phalanx produced the greatest degree of pain.

The roentgenograms taken at this time revealed the sclerotic bone of the proximal phalanx. An area of lucency could be seen in the distal portion of the phalanx in the anterior view. Evidence of previous surgical intervention was present. No true lateral x-ray had been taken prior to this examination. When this view had been obtained, a unique lesion was seen to rest against the anterior cortex of the bone, outlined by a thin wafer of sclerotic material.

With this specific knowledge of the position of the nidus, the phalanx was exposed through a mid-lateral incision. Against the volar surface, a round reddish-brown spherical mass was found to be encapsulated by a thin membrane. This was easily removed with a scoop of the curette. After the operation, pain disappeared and swelling began to subside.

The differential diagnosis from the roentgenogram in a case of osteoid osteoma must

FIG. 1

FIG. 2

FIG. 3

Fig. 1: Roentgenogram of a centrally located nidus in the metacarpal of a twelve-year-old girl (Case 1). There is marked sclerosis of the entire shaft. The lytic nidus can be seen in the distal shaft just proximal to the epiphyseal line. This nidus is unusually large and extends past the mid-line toward the opposite cortex.

Fig. 2: Roentgenogram of a nidus in a cortical location (Case 4). The sclerotic response of the cortex does not involve the medullary cavity or opposite cortex. The nidus is of the type called "ring sequestrum".

Fig. 3: Roentgenogram of a periosteal type of osteoid osteoma (Case 5). The nidus is clear and is outlined by a thin line of osteoblastic periosteum. It has the appearance of a bubble lying against the anterior cortex of the phalanx.

include syphilis of bone; this is the great imitator. Syphilitic dactylitis can produce diffuse sclerosis of the shaft and even a questionable nidus. Tuberculosis of the phalanx or metacarpal can appear similar to osteoid osteoma. There are forms of osteomyelitis and Brodie's abscess which give a picture quite like that of osteoid osteoma. However, once the physician has seen the appearance of osteoid osteoma on the roentgenogram, he should easily recognize the characteristic picture.

BONES INVOLVED

The femur and tibia are the most commonly involved bones. The bones of the foot are involved twice as often as those of the hand. Twenty-two reported cases of osteoid osteoma in the hand have been collected from the literature. To these have been added the six newly reported cases of the author. This gives a total of twenty-eight cases of osteoid osteoma in the hand. We have charted these as a matter of interest (Fig. 4). The case, described by Jaffe and Mayer [11], of occurrence in the metacarpal is not included as it seems to be so unusual that it stands alone.

The terminal phalanx is a rare site for osteoid osteoma. We have been able to find only two cases. One was described by Chandler and Kaell in 1950, and the other by Lichtenstein in 1952.

The middle phalanx does not seem to be affected by this tumor. There may be such a case included in a report which does not specify the bone involved.

The proximal phalanx [3, 12, 18] is the most common site for osteoid osteoma. In eight cases from the literature and in two new cases of the author's, the tumor was located in this phalanx. It is of great interest to note that the three known cases of the periosteal type of osteoid osteoma were found in this bone.

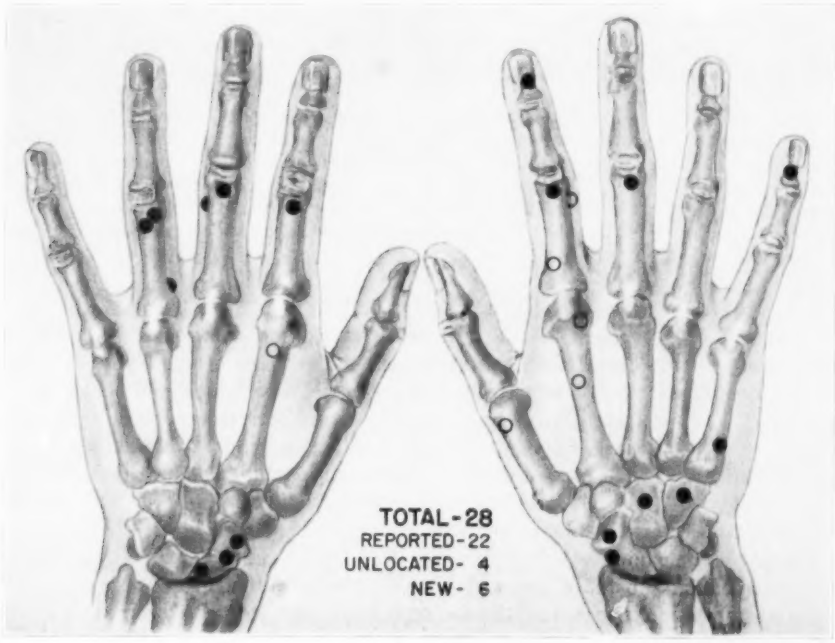

FIG. 4

Anatomical chart for the location of the known cases of osteoid osteoma in the hand. The solid dots represent reported cases. The circles represent newly reported cases from this paper. The location of the tumor in four reported cases [21] was not specifically given.

The metacarpal is also a fairly common site. In one case from the literature [11] and four cases of the author's, this bone has been involved.

Carpal bones in general have not been involved except the navicular (scaphoid). This bone is the site of the tumor in five cases from the literature [20, 22]. It is unusual that this single bone has been the location for almost all lesions in the carpal area. There is one reported case [23] of osteoid osteoma in the capitate. Another author [16] found this entity in the hamate bone.

TREATMENT

The treatment of osteoid osteoma is surgical extirpation of the nidus. This is also the only method by which a positive diagnosis may be made. Often it is extremely difficult to locate the nidus. Roentgenograms taken at the time of operation are helpful. No new nidus has ever been found to appear, once excision has been accomplished. The author feels that so-called "recurrence" may represent persistence due to failure to remove completely the nidus at operation. It is surprising that relief of symptoms may occur even when the nidus is not totally extirpated.

Treatment with antibiotics has not been found to have any effect on this tumor. Full courses of the frequently used drugs have been tried in proved cases without changing the development of the clinical picture.

No treatment with the roentgen ray is known to have been tried; it might possibly alter the course of the tumor. There would then be the problem of proving what sort of entity was treated.

It is of great interest to speculate on the course of the untreated tumor. In only one instance has this been reported in a hand. Moberg [14, 15] was able to follow what appeared by roentgenogram to be an osteoid osteoma of the fifth metacarpal. Pain did subside after eighteen months, but evidence of the lesion could be seen thirteen years after discovery. The author has tried this method with the cooperation of a patient, but pain wore down the resistance and the tumor was excised.

CASE 6. J. C., a woman thirty-two years old, had a cortical type of nidus in the metacarpal of the right thumb. Extirpation of this had been attempted without removing the nidus. The type of tumor was discussed with the patient. Her cooperation was sought in avoiding surgery if the pain did not cause great disability. Full courses of aureomycin, penicillin, terramycin, and sulfadiazine were given. No change in the symptoms was noted. The aching could be relieved for twelve hours by five grains of aspirin. After eight months of the aching pain, the patient asked that the tumor be removed. This was done and complete relief from pain was immediate.

PATHOLOGICAL FINDINGS

Upon exposing the bone beneath the periosteum, the cortical thickening of the osteoid osteoma can be seen. This difference in sclerotic bone change becomes readily apparent when an osteotome is used to section the bone. In the bite of an osteotome, normal bone feels like wet hardwood, but the incising of sclerotic bone feels as though one were hewing brittle ivory. The cortical fragments splinter easily and tend to laminate while being removed. The nidus of the osteoid osteoma is generally found to be brownish-red in color. Its consistency on curettage feels like that of soft cancellous bone. In the case of the periosteal type of osteoid osteoma, no bone division was necessary.

The microscopic findings consist of a well demarcated nidus of osteoblastic tissue with osteoid intercellular substance. Around this area, the bone tends to be sclerotic.

No attempt is made to discuss the etiology of osteoid osteoma. To some it may appear a true neoplastic variant; to others, the etiological source is in the realm of infection. No report, however, has been found of a positive organism cultured from an osteoid osteoma. In this paper, it is discussed as an entity because there is a definite clinical picture associated with definite pathological findings and certain relief of symptoms.

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DISCUSSION

Dr. Michael L. Mason, Chicago, Illinois: Moberg, in a recent article [a] has fully discussed the usual roentgenographic appearance of the lesion and has brought out the fact that, although the x-ray appearance is usually characteristic, confusion may arise in the case of bone abscess, osteitis without abscess, syphilitic osteitis, or even a healing march fracture.

In a patient whom we have seen, the swelling of the finger resembled a spina ventosa, although the x-ray appearances were typical of osteoid osteoma. This patient, who was cared for by Dr. Sumner Koch, is particularly instructive in that films taken over a period of two years show the typical course of the lesion. Two years previously the patient, a boy of twelve, had suffered a longitudinal fracture of the proximal phalanx of the right index finger. Healing was uncomplicated. One year later swelling appeared and night pains developed, easily controlled by aspirin. There was no interference with motion. X-rays taken at that time showed the barest suggestion of periosteal thickening. One month later films showed a definite area of lucency in the distal end of the phalanx, along with increased thickening of the cortex. Two months later these roentgenographic findings were still more marked. By the time he was seen, the area of lucency was still larger and the cortex was markedly thickened. At operation the thick cortical bone was chiseled away and a granulomatous marrow was exposed. Apparently all of the nidus had not been removed, because the pain and swelling reappeared in some three months and films at this time showed the area of lucency as before. This area was then completely removed, and only a thin bone shell was left. Pain and other symptoms subsided and there has been no recurrence to date (three years).

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(*Continued on page 936*)

ASEPTIC NECROSIS OF BONE IN CAUCASIANS WITH CHRONIC HEMOLYTIC ANAEMIA DUE TO COMBINED SICKLING AND THALASSEMIA TRAITS

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The purpose of this paper is to describe the occurrence of aseptic necrosis of bone in Caucasians with chronic hemolytic anaemia due to the combined presence of sickle-cell and Cooley's traits. We wish to emphasize that these bone changes also occur in Negroes with classical sickle-cell anaemia[17, 21]. In children these changes are indistinguishable both clinically and roentgenographically from Perthes' disease and in adults they must be differentiated from bone changes due to Gaucher's disease, metastatic neoplasms, caisson disease, Paget's disease, or changes following fracture or dislocation of the hip.

Other less specific bone changes occur in these cases, but they are of the nature exhibited by patients with any chronic hemolytic anaemia.

HISTORY

The authors have found only three cases of anaemia due to the occurrence of sickle-cell and Cooley's traits in the same patient reported in the literature of the United States. The first case was described by Powell, Rodarte, and Neel in 1950. The second and third cases were reported by Sturgeon, Itano, and Valentine in 1952, and Wasserman, Phelps, and Hertzog in 1952. In the Italian literature Sylvestroni and Bianco had previously reported eight cases occurring in five families.

Sickle-cell anaemia was first described by Herrick in 1910. It occurs almost exclusively in Negroes, although Neel and his associates stated that twenty-six authentic cases have been reported in Caucasians whose immediate heredity showed no Negro ancestors. Most of these were patients whose lineage was either northern Mediterranean, Mexican, or Mayan Indian. True sickle-cell anaemia occurs in patients who have inherited the trait from each parent and are homozygous. The sickle-cell trait occurs in 7 to 10 per cent. of all Negroes, but these heterozygous individuals do not have sickle-cell anaemia. They are said to have sickle-cell trait or "sicklemia".

Cooley's anaemia is synonymous with erythroblastic anaemia, leptocytosis, Mediterranean anaemia, or thalassemia major. It was first described by Cooley, Witwer, and Lee in 1925. This is the severe form of the disease in which the patient has inherited the trait from each parent and is, therefore, homozygous. If the patient inherits this trait from only one parent, he may exhibit a mild anaemia which has been called "Cooley's trait", "thalassemia minor", "target-oval cell syndrome", "familial microcytic anaemia" or "microcytemia"[30, 33].

We have observed three patients in two Caucasian families, in whom both the sickle-cell and Cooley's traits occurred simultaneously. Two of these patients had aseptic necrosis of the heads of the femora and one of them had similar changes in the heads of the humeri. In addition, Powell, Rodarte, and Neel reported that their patient had flattening of the vertebrae and mushrooming of the heads of the femora * (Figs. 1-A and 1-B). This patient also had aseptic necrosis of the heads of the humeri. It is not uncommon to see aseptic necrosis of the femoral head in Negro children or adults with sickle-cell anaemia. One Negro, aged thirty-three, with aseptic necrosis of both hips has sickle-cell anaemia and target cells, but she has no microcytosis or decreased fragility indicative of thalassemia.

* We are grateful for permission to reproduce roentgenograms of this patient. They were obtained from the Radiology Department of Scott and White Hospital, Temple, Texas.

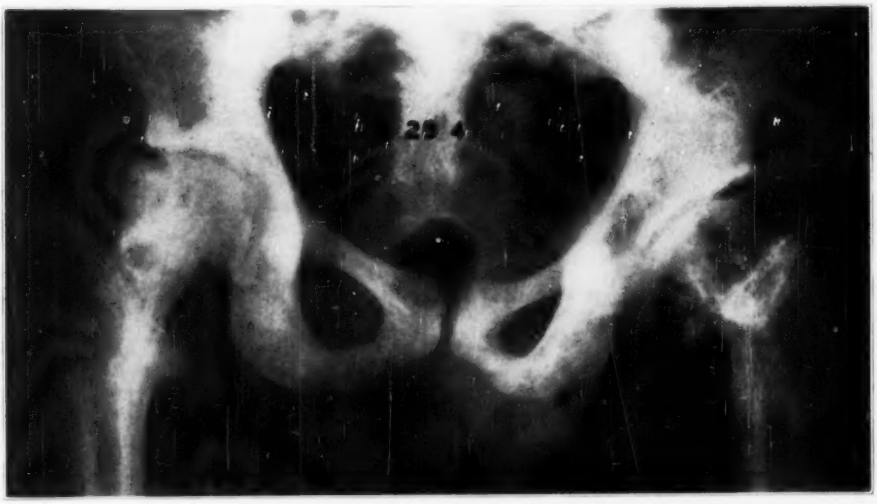

FIG. 1-A

Fig. 1-A: Mike D. Roentgenogram of both hips and pelvis shows marked flattening of the heads of both femora with cystic and sclerotic changes, shortening of the femoral neck, and involvement of upper portion of both femoral shafts. Note also cystic and sclerotic changes of the pelvis. (Courtesy of X-Ray Department, Scott and White Hospital, Temple, Texas.)

Fig. 1-B: Anteroposterior view of thoracolumbar spine shows marked biconcavity and flattening of the vertebral bodies with generalized sclerosis. (Courtesy of X-Ray Department, Scott and White Hospital, Temple, Texas.)

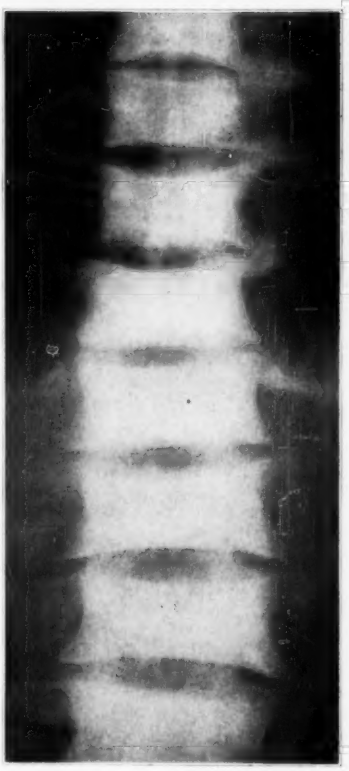

FIG. 1-B

Our patients and those who have been reported elsewhere exhibit a chronic hemolytic anaemia with sickling, microcytosis, decreased fragility, and target cells. These patients have had splenomegaly, jaundice, and crises, all of which are common to sickle-cell anaemia. Clinically the patients are indistinguishable from those with sickle-cell anaemia, but genetically they do not have a true sickle-cell anaemia; their siblings have shown either one or both traits or neither trait. In the families studied, one parent has had sickle-cell trait and the other has had Cooley's trait.

Neel has suggested that perhaps some of the cases reported as sickle-cell anaemia in Caucasians might rather show sickle-cell trait as well as Cooley's trait. Our B. family, in which Anne and her sister Frances have this type of anaemia, were reported as cases of true sickle-cell anaemia in 1937 [20]. Our patient Anne B., whose mother and father were both Sicilian, shows roentgenographic changes in the heads of the femora (Fig. 2-A) and heads of the humeri (Figs. 2-B and 2-C) similar to those in a case of sickle-cell anaemia reported by Hamburg in 1950. Her sister, Frances B., has anaemia similar to Anne's but milder and, at the age of thirty-six, does not yet exhibit roentgenographic evidence of bone changes.

Anne B., a female of Sicilian ancestry, was first seen in October 1943, at the age of twenty-nine, complaining of pain in the right hip.

The patient stated that she had had rheumatic pains in arms and legs for about ten years. In 1938 she had severe pain in the left hip associated with severe hemolytic anaemia; at that time she was hospitalized in a New England hospital for three months. The right hip had begun to be painful in 1941 and was at that time the more painful of the two hips. She had had a splenectomy for "Banti's disease" in 1922, at the age of nine.

FIG. 2-A

Anne B. at admission. Roentgenogram of both hips showed flattening and fragmentation of both femoral heads with cystic and sclerotic areas. There was also shortening of both femoral necks.

FIG. 2-B

FIG. 2-C

Roentgenograms made in December 1952 showed cystic and sclerotic changes in the heads of right and left humeri, as well as flattening of both humeral heads.

The patient's father had died of "blood disease" diagnosed as "myeloid leukaemia". He had had jaundice and splenomegaly. The mother was living and well, but showed sickle-cell trait. One sister, aged twenty-seven, has blood disease like the patient and has crises but no bone disease. Five other siblings have either sickle-cell trait or Cooley's trait. The patient, her grandfather, father, one brother, one aunt, and two cousins, have moderate bilateral flexion contractures of the proximal interphalangeal joint of the fifth finger without local bone involvement.

The patient was a small white female who did not appear ill. Her sclera appeared yellow-tinged. There was a mitral murmur and the cardiac outline was enlarged. Examination of the lower extremities showed marked limitation of motion in both hips; passive motion of the hips was painful. The patient walked with a duck-waddle gait. The left upper quadrant showed a splenectomy scar which was well healed.

Laboratory Findings

The urine was normal. The Kline test was negative.

Blood chemistry was normal.

Red blood cells	3,800,000 per cubic millimeter
Reticulocytes	12.0 per cent.
Hemoglobin	8.1 grams per 100 cubic centimeters of blood
Differential of white cells showed:	
Neutrophils	56 per cent.
Lymphocytes	38 per cent.
Monocytes	5 per cent.
Eosinophils	1 per cent.

Blood film showed anisocytosis, poikilocytosis, hypochromia, numerous target cells and normoblasts, basophilic stippling and oval cells, as well as occasional sickled cells.

Hypotonic fragility test	0.30–0.20 per 100 cubic centimeters

Fresh preparation showed 100 per cent. sickling in four hours.

Icterus index	10 (Under 10 is normal.)
Sedimentation rate (Wintrobe method)	14 millimeters per hour

Treatment

The patient was operated upon in May 1944, at which time a Vitallium-mold arthroplasty of the right hip was done. Recovery was uneventful. In October 1944 a similar operation was done on the left hip. The postoperative course was marred by pulmonary emboli due to phlebothrombosis which necessitated ligation of the femoral vein. The patient recovered without further complications and is regularly employed as a factory worker. She still walks with a duck-waddle gait, but pain is not a prominent symptom. Her anaemia is moderate.

Pathology Report

Tissue removed from the head of the right femur and hip joint showed degenerating bone and articular cartilage with areas of fibrosis. The bone marrow showed diffuse myeloid and erythroid hyperplasia. Red blood cells showed evidence of sickling.

Roentgenographic Reports

Anteroposterior view of the pelvis and femora, made October 8, 1943, showed mottled moth-eaten destruction of the heads and necks of both femora interspersed with dense sclerotic bone spicules. The process was more advanced on the left where there was marked flattening of the articulating margin of the head. The medullary portions of the shafts of both femora had a coarse cystic architecture, suggesting separation of the bony trabeculae. There was slight thickening of the cortical margins of both femora without definite periosteal changes. The left ilium also showed coarse interlacing trabeculae.

Roentgenographic examination of the shoulders on December 12, 1952, showed irregularity of both humeral heads. There was marked mottling and osteoporosis in the upper portion of both humeri with some cystic areas and other areas of extremely sclerotic bone. The medullary canal of the upper portion of each humerus was wider than normal, and there was loss of trabeculation in this area.

The second case with bone changes to be reported here is that of Ignazio V. who is now twelve years old. He was first seen by us at the age of nine. His mother and father are both Sicilian. The aseptic necrosis exhibited in the roentgenograms is confined to the head of the left femur (Figs. 3-A, 3-B, and 3-C) and has been roentgenographically indistinguishable from Perthes' disease.

Ignazio V., a white boy of Sicilian ancestry, was first seen by us in March 1949, at which time he was nine years old. His chief complaint was severe pain in the left hip of three days' duration. Onset had been sudden.

The patient was a sallow, white male, slightly smaller than his brother who is two years younger. He was lying in bed very quietly in considerable pain. It was impossible to move his left hip because of pain; there was tenderness over the head of the left femur anteriorly. Further examination revealed his sclera to be yellow-tinged. The left upper quadrant showed a splenectomy scar which was well healed.

The patient had always been in poor health. At the age of seven months he had had pneumonia and had been anaemic. At the age of two years it had been discovered that he had splenomegaly. He had had numerous bouts of bone and joint pain accompanied by mild jaundice. He had been admitted to Mount Sinai Hospital of Cleveland four times in 1947, with diagnosis of Cooley's anaemia, severe epistaxis, right hip pain, and pneumonia. In July 1947 a splenectomy had been performed for hemolytic anaemia.

Pathology Report No. 55–118: The spleen showed marked chronic passive congestion with multiple infarcts. There was marked evidence of hematophagia. The red blood cells showed some evidence of sickling.

His four grandparents had been friends in Sicily. Maternal grandparents are living and well. Mother is living and well. Her blood studies showed 100 per cent. sickling in twenty-four hours without anaemia. Father is living and well. His stained blood smear showed target cells. Three younger siblings are living and well. One brother has had blood studies which were completely normal. Another brother has target cells. A wet smear preparation of his sister's blood showed sickling.

The patient appeared to be in a crisis, but sickle-cell preparations at that time were reported negative. X-rays of both hips failed to show any abnormality. The patient remained in Buck's traction. A second sickle-cell preparation was reported to show sickling. After two weeks roentgenograms of the hips and pelvis began to show some changes.

FIG. 3-A

Ignazio V.: Anteroposterior and lateral views of both hips showed only juxta-epiphyseal osteoporosis of the left femoral neck.

FIG. 3-B

Ignazio V.: Roentgenograms approximately one year later than Fig. 3-A showed cystic and sclerotic changes in the left femoral head. These changes were indistinguishable from aseptic necrosis due to any cause.

FIG. 3-C

Ignazio V.: Roentgenogram made forty-four months after original onset of pain in left hip. The patient had been treated with Buck's traction in a recumbent position for approximately sixteen months. There was only slight deformity of the femoral head with some shortening of the femoral neck. The aseptic necrosis may be considered healed.

Roentgenographic Findings

April 1949: There was demineralization of the neck and upper shaft of the left femur. The involvement in this hip was confined to the neck and shaft of the femur, since the left epiphysis compared with the right epiphysis was of normal density. The relative density of the proximal femoral epiphysis on the left side was due to the demineralization of the neck of the femur rather than to changes in the epiphysis.

May 1950: Anteroposterior and lateral views of the pelvis and hips showed irregularity of the margin of the head of the femur and irregularity of ossification in this region. There were multiple radiolucent areas interspersed among some areas of increased density. This film was consistent with the diagnosis of Legg-Perthes disease.

December 2, 1951: Anteroposterior and lateral views of both hips showed some flattening of the head of the left femur with widening and shortening of the neck. The epiphysis was open. There was some degree of external rotation of the femur.

December 8, 1952: Anteroposterior and lateral views of both hips showed some flattening of the head of the left femur. There was narrowing and shortening of the neck of the left femur and some external rotation of the femur. Films showed complete healing of the aseptic necrosis which had previously been present.

Laboratory Findings

The urine was normal. The Kline test was negative.

Red blood cells	3,200,000 per cubic millimeter
Reticulocytes	18.0 per cent.
Hemoglobin	6.4 grams per 100 cubic centimeters of blood
Hematocrit	30 per 100 cubic centimeters of blood
Differential of white cells showed:	
Neutrophils	51 per cent.
Lymphocytes	42 per cent.
Monocytes	4 per cent.
Eosinophils	2 per cent.
Basophils	1 per cent.

Blood film showed anisocytosis, poikilocytosis, hypochromia, multiple target cells and normoblasts, occasional oval cells, and basophilic stippling, as well as occasional sickled cells.

Hypotonic fragility test	0.30–0.20 grams per 100 cubic centimeters.

Fresh preparation showed 100 per cent. sickling in one hour (on other occasions preparations were reported negative for sickling).

Icterus index	24 (Less than 10 is normal.)
Sedimentation rate (Wintrobe method)	33 millimeters in one hour

The patient was transferred from Mount Sinai Hospital of Cleveland to Rainbow Convalescent Hospital for Children. He remained recumbent in Buck's traction for fourteen months; then he was allowed up with an ischial weight-bearing brace which he wore for three more months. His total period of non-

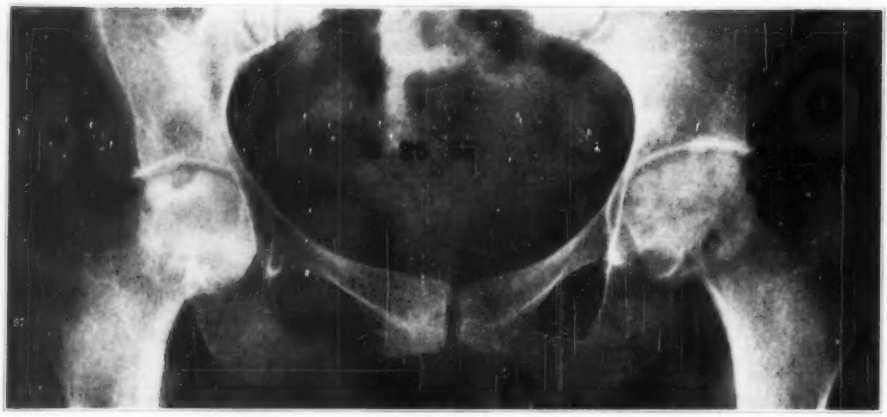

FIG. 4

Annie C.: Roentgenogram of pelvis and hips showed cystic and sclerotic changes in each femoral head with flattening of the left femoral head. Aseptic necrosis is due to sickle-cell anaemia only. This patient has target cells but not thalassemia, because microcytosis and decreased hypertonic fragility are not present.

weight-bearing was almost twenty months. At the end of this time it was felt that restitution of the proximal femoral epiphysis was sufficient to allow weight-bearing.

At present the patient has no limp and no limitation of motion in his left hip joint. However, he has been seen numerous times with pains in his back or one extremity. Complete examination and roentgenograms on these occasions have been normal. On one of these occasions, December 3, 1950, the patient was seen with a moderate effusion of the left knee; it was not aspirated but disappeared with bed rest in forty-eight hours. More recently, December 22, 1952, the patient was seen with fractures of both bones of the right forearm. No evidence of pathological changes could be seen in roentgenograms of the fractured forearm.

In addition to the Caucasian patients we have been privileged to see a case of aseptic necrosis of the heads of both femora in a Negro (Fig. 4) whose blood also shows sickling and numerous target cells. This type of aseptic necrosis is roentgenographically and clinically indistinguishable from aseptic necrosis due to any other cause.* The only other member of her family available for examination is a son, aged fifteen, whose blood smear showed target cells and whose sickle-cell preparation was positive. He has no anaemia or bone changes.

Annie C., Negro female, aged thirty-three, has known that she had sickle-cell anaemia since she was six years old. She has had numerous episodes of joint pains; however, the pain in her hips has become more persistent and has been constant for practically one year. The left hip became painful approximately two years ago and during the past year the right hip has begun to be painful. About two weeks previous to admission the patient had had a blood transfusion for anaemia, after which she vomited blood.

She has had numerous hospitalizations for transfusions, pelvic inflammatory disease, and one confinement in 1937, at which time a normal male child was delivered.

Her mother died of tuberculosis. Her father is living and well in Alabama; she has no siblings. One son is living and well.

Physical examination showed a young colored woman who was obviously markedly anaemic and appeared extremely ill. Sclera appeared yellow-tinged. Examination of the abdomen showed marked tenderness in both lower quadrants with some rigidity. The spleen was palpable and not tender. Examination of both lower extremities showed the hips to be markedly limited in all directions and motion against resistance was painful. Extremes of limited motion were also painful.

Laboratory Findings

Red blood cells	2,200,000 per cubic millimeter
Reticulocytes	14 per cent.
Hemoglobin	6.0 grams per 100 cubic centimeters of blood

* We are grateful to Dr. Moses Leeb and Dr. Ernest Stokien for permission to include the report of Annie C. and her son.

Hematocrit	22 per 100 cubic centimeters of blood
Mean corpuscular volume	100 cubic micra
Mean corpuscular hemoglobin concentration	27 per 100 cubic centimeters of red blood cells
White blood cells	17,700 per cubic millimeter
Normoblasts	125 per 100 white blood cells
Blood film showed numerous target cells and sickle cells.	
Sickling tests were positive.	
Icterus index	25

This patient's most recent hospitalization was in March 1952. Since that time she has been able to work and has been free from pain in her hips, under cortisone therapy administered by her physician.

Recent roentgenograms of her hips show no appreciable changes over the roentgenograms seen in March 1952. At that time flattening of the heads of both femora was evident. There were areas of apparent density with other intervening areas of vacuolization. There was some narrowing of both spaces, and some demineralization of the proximal portions of the shafts of both femora.

Diagnosis: Aseptic necrosis of the heads of both femora.

(The fifteen-year-old son of Annie C. showed target cells on the routine blood smear and his wet preparation for sickle cells was positive.)

PATHOPHYSIOLOGY

Genetically these patients do not have a true sickle-cell anaemia, but clinically they meet all the criteria of sickle-cell anaemia, except that the anaemia is less severe. Hematological studies also meet all the criteria of sickle-cell anaemia, as well as those of Cooley's anaemia and a decreased red-blood-cell fragility. Electrophoretic studies have shown that the structure of the hemoglobin found in sickle cells is different from that in normal red blood cells. Four distinctly different electrophoretic patterns have been described[23]. Cells containing sickle-type hemoglobin are usually normal in shape in the circulating blood but quickly assume the sickle shape when they are exposed to an atmosphere of diminished oxygen tension. Blood containing sickled cells is more viscous and the cells themselves are more firm than normal cells.

Diggs, Pulliam, and King studied the skeletons at necropsy in thirty-nine cases of sickle-cell anaemia. In their cases the long bones contained red marrow. They felt that this was not only the result of increased erythrogenesis but was also due to congestion. They concluded that two factors appear to be working in opposite directions,—one, the hyperplastic bone marrow, tending to increase at the expense of bone, and the other tending to restore bone. We would suggest that much of the roentgenographic evidence of sclerosis may be the result of bone infarcts.

The subject of bone changes in sickle-cell anaemia has been studied by Diggs, Pulliam, and King; Graham; Wade and Stevenson; and Grinnan. They have all commented on the presence of necrosis in the bone marrow.

In addition to necropsy studies, there have been many reports on the roentgenographic changes in bones of patients with sickle-cell anaemia. Harden described the "hair-on-end" appearance of the skull. Koch and Shapiro were principally impressed with the porosity in the long bones. Caffey and later Danford, Marr, and Elsey described bone changes, mostly in infants, but did not mention aseptic necrosis. In 1952 Ehrenpreis and Schwinger described the appearance of biconcavity of vertebrae, aseptic necrosis of the head of the femur, and osteosclerosis of the head of the humerus in Negroes with sickle-cell anaemia. We have described roentgenographic evidence of similar changes in patients who do not have sickle-cell anaemia but rather a hemolytic anaemia due to the presence of sickle-cell trait and thalassemia. Some of our patients have exhibited less specific changes ascribable to any bone marrow with erythropoietic deficit.

The rigidity and increase in viscosity of sickle-cell blood, as well as the congestion, stasis, and necrosis reported by others[16, 18, 19, 27], strongly suggest the presence of emboli in the bone marrow. The presence of emboli has been demonstrated in many organs at necropsy on patients with sickle-cell anaemia. The findings in the spleens of our patients Ignazio V. and Anne B. included congestion, fibrosis, and infarcts. The aseptic

TABLE I

COMPARATIVE BLOOD STUDIES

Name	Age (Years)	Sex	Race	Red Blood Cells (Per Cubic Millimeter)	Hemoglobin (Grams)	Hematocrit (Per 100 cubic Centimeters of Blood)	M.C.V.* (Cubic Microns)	M.C.H.** (Micromicrograms)	M.C.H.C.*** (Per 100 Cubic Centimeters of Red Cells)	Reticulocytes (Per Cent)	White Blood Cells (Per Cubic Millimeter)	Sickling	Stained Smear	Hypotonic Fragility**** (Grams per 100 Cubic Centimeters)	Diagnosis	Bone Changes
Mike D. Reported by Powell and Associates [9]	41	M	W Sicilian	4,000,000	8.5	30	75	21	28	10.0	6,000	Positive	Target, oval, and stippled cells, rare sickle cell. 180 nucleated red blood cells per 100 white blood cells.	0.36–0.10	Hemolytic anaemia due to presence of both sickle-cell and thalassemia traits.	Aseptic necrosis of heads of femora and humeri and pelvis. Flattening, sclerosis, and biconcavity of vertebrae.
Anne B.†	38	F	W Sicilian	3,880,000	8.1	32	84	21	25	12.0	8,400	Positive	Target, oval, and stippled cells, poikilocytosis, hypochromia. 114 nucleated red blood cells per 100 white blood cells.	0.30—less than 0.20	Hemolytic anaemia due to presence of both sickle-cell and thalassemia traits.	Aseptic necrosis of heads of femora and humeri. Roentgenograms show marked sclerosis.
Frances B. (Sister of Anne)	38	F	W Sicilian	4,200,000	8.3	36	86	19	23	6.0	6,700	Positive	Target, oval, and stippled cells. Poikilocytosis-anisocytosis. 34 nucleated red blood cells per 100 white blood cells.	0.30—less than 0.20	Hemolytic anaemia due to presence of both sickle-cell and thalassemia traits.	None.
Ignazio V.†	14	M	W Sicilian	4,380,000	9.2	30	78	21	27	4.9	14,000	Positive	Target, oval, and sickle cells. Hypochromia and poikilocytosis. 240 nucleated red blood cells per 100 white blood cells.	0.30—less than 0.20	Hemolytic anaemia due to presence of both sickle-cell and thalassemia traits.	Aseptic necrosis of head of left femur.
Annie C.	33	F	C Negro	2,200,000	6.0	22	100	27	27	14.0	17,700	Positive	Numerous target cells and sickle cells. 120 nucleated red blood cells per 100 white blood cells.	0.44–0.32	Sickle-cell anaemia	Aseptic necrosis of heads of both femora.

* Mean corpuscular volume. ** Mean corpuscular hemoglobin. *** Mean corpuscular hemoglobin concentration. **** Concentration of sodium chloride.
† The figures reported in the table represent interval blood studies which are more truly significant than those taken from hospital charts in time of crisis.

necrosis which we have observed on roentgenograms is probably due to the formation of emboli, causing infarction in the bones. Pugh has stated that this does occur and that the bone changes in sickle-cell anaemia are similar to, but less severe than, those in Cooley's anaemia. The blood supply to the head of the femur is known to be less abundant than that of other skeletal regions. This may account for the inability of this area to deal effectively with congestion and clotting which lead to emboli and infarcts. Caisson disease which causes gas emboli is often manifested by aseptic necrosis in this area.

It has been observed that the skeletal changes in sickle-cell anaemia are more common in weight-bearing bones and also more common in older age groups. In thirty-nine patients studied at necropsy by Diggs and his associates, only one was over the age of thirty-one years. Patients with true sickle-cell anaemia rarely live beyond the third decade. The patient reported by Hamburg was a Negro male, aged fifty-five. If sickle-cell-anaemia patients lived longer, they would probably show more profound bone changes. It appears that patients with combined Cooley's and sickle-cell traits have a milder anaemia and greater longevity than patients who are homozygous for either trait. Neel's patient was a male Sicilian, forty-one years of age, and our patient Anne B. is now thirty-eight years old. She has had hip disease since she was thirty, but even then she was beyond the age of demise for most patients with true sickle-cell anaemia. The patient, Annie C., a Negro female, aged thirty-three, has had complaints referable to her hip joints only during the past year. She too is beyond the age to which patients with sickle-cell anaemia usually live.

In Ignazio V. aseptic necrosis of the head of the femur developed at a relatively early age. However, it is well to point out that bone changes in both sickle-cell and Cooley's anaemias have been reported during the first year of life. It is possible that the appearance of aseptic necrosis of the head of the femur in our young patient Ignazio V. may be only a coincidence and that he may have Perthes' disease of idiopathic origin. However, of six cases of combined sickle-cell trait and Cooley's trait of which we have knowledge three show evidence of aseptic necrosis of the head of the femur and this seems more than just coincidence. Because this disease resembles sickle-cell anaemia so closely, we are inclined to believe that the occurrence of aseptic necrosis in cases of sickle-cell anaemia has a similar etiology.

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DIRECT SURGERY IN SEGMENTAL ARTERIOSCLEROSIS * †

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For many years attention has been directed principally toward indirect measures of treatment in obliterative arterial disease. The many reports pertaining to experiences with lumbar sympathectomy in the treatment of arteriosclerosis of the lower extremities have served to establish the indications, expectations, and limitations of this form of treatment. Non-surgical measures utilizing various drugs which diminish the activity of the sympathetic nervous system have been found to be entirely inadequate for patients with arteriosclerosis. Direct surgical attack on the obstructive arterial lesions of arteriosclerosis has been investigated since 1947. The techniques have taken two directions — thrombo-endarteriectomy and segmental resection with graft replacement.

Thrombo-endarteriectomy or intimectomy has been developed in various manners [1, 2, 4, 6, 7, 11, 12, 15, 17, 18, 21] which differ from each other only in detail. The methods reported by these authors all result in the removal of the inner portion of the diseased vessel, which consists of its intima and the internal portions of the media. When the arteriotomy wounds necessary for this removal have closed, the end result is a vascular cylinder lined by the plane of separation through the media of the vessel. Such a surface is wettable, if not absorbent; the success of all such methods has depended upon meticulous, continuous heparinization usually administered locally through a tiny polyethylene tube introduced into the artery above the area of the operation[8]. Thrombo-endarteriectomy proves dependable only in arterial channels of major size or, in the case of medium vessels such as the superficial femoral, only for removal of a short obstruction. Consequently, its continued use is largely confined to the lower end of the aorta and the common iliac arteries.

Surgical treatment of segments of obstruction to the major vessels which provides for an intimal lining consists of resection of the segment and replacement with a vessel graft. The use of vein grafts for this purpose has been reported by Fontaine and his associates [6, 7], Kunlin, Bouchard, and Julian and Dye.

Certain clinical features are recognizable in cases of segmental occlusion in arteriosclerosis which form a basis for the primary selection of patients for such treatment. The patients in this group ordinarily have, as their sole complaint, intermittent claudication. The other common complaints of arteriosclerosis, such as rest pain, cramps, coldness, pallor and paraesthesia, are usually absent. This is due to the fact that in segmental obstruction the slow development of the occlusion stimulates the formation of an adequate collateral system, which, because it re-enters the main channel below the obstructed segment, is sufficient during rest to supply all needs of the tissues. During exercise, however, such a collateral system is unable to provide the increased blood flow required and pain results. Because of the adequacy of supply during rest, these patients often show no signs in the tissues of the feet suggestive of arterial insufficiency. There is no ulceration, cyanosis, or atrophy of the skin. "Skeletonization" caused by atrophy of the small muscles of the foot is similarly absent. On examination it is noted that in spite of the absence of ischaemic

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FIG. 1

FIG. 2

Fig. 1: Preoperative arteriogram of a man, fifty-five years old. Onset of symptoms had been at twenty years, following the femoral fracture.

Fig. 2: Aortogram of a man, forty-eight years old, made eleven years after fractures of the transverse processes of the lumbar vertebrae.

changes there is an unexpectedly high loss of palpable pulses and a high, relatively abrupt diminution in the oscillometric indices on the limb.

This combination of symptoms and signs—the single symptom of intermittent claudication, the lack of signs of tissue ischaemia, and the high loss of pulses in the extremity—constitutes a syndrome on the basis of which further study is indicated. Such further study consists of roentgenographic outlining of the arterial system, either the lower abdominal aorta and its branches or the vessels within the extremity being visualized, depending on the route of injection of the contrast medium. The arteriogram often shows the entire area of pathological involvement, including the upper end of the obstruction, the collateral circuits, and the main channel distal to the obstruction which has been filled through the collaterals.

Certain mechanical features of the obstructions ordinarily seen are of interest. These segments are found in fairly uniform locations. The aortic bifurcation, the femoral bifurcation, and the adductor hiatus are the common points at which short segments occur. Long areas of obstruction most often seem to begin or end at one of these locations. Obstruction of the popliteal artery is a less frequent but characteristic location. These points in the arterial system of the lower extremities seem to be those at which the vessel is continually subjected to stress in normal activity. The bending of the vessel at the groin and knee and the constant contact with the rigid adductor hiatus in the adductor magnus tendon provide such trauma. It is less clear how trauma plays a part in the selection of the aortic bifurcation as a favorite site for arteriosclerotic obstruction. The abrupt, equal division of the forceful aortic stream into two channels may provide an extra expansile force here.

More distinct evidence of the factor of trauma in chronic segmental occlusion was seen in two of our cases in which the obstruction was opposite a long healed fracture. In one of these, the arterial lesion was directly opposite an old healed fracture of the femur (Fig. 1). In the other, the aorta and the common iliac arteries were the site of the arterial disease in a patient whose lumbar transverse processes had been fractured by an indirect trauma (Fig. 2). Resection and replacement by a vein graft restored the femoral arterial channel in the former patient and resection of the aortic bifurcation is planned for the other. These cases provide evidence that arterial changes may be late complications of fractures.

It is the conclusion of most authors reporting cases of resection and replacement by a graft that adequate filling of the channel distal to the obstruction and the absence of a significant degree of arterial disease in the main channel both above and below are necessary before success may be expected from the procedure.

Replacement of the defect produced by resection of an obstructive segment in the lower extremity, particularly in the superficial femoral artery, has been accomplished through the use of the autogenous superficial femoral vein or saphenous vein in most cases. We have previously reported, in addition, the use of homologous saphenous veins for replacement of the superficial femoral artery.

Arterial homografts for the replacement of arterial segments was first reported in a clinical series by Gross and his coworkers in 1949. Gross later used homologous artery grafts to replace the defect in the thoracic aorta following resection of a coaretation. Swan, Maaske, Johnson, and Grover reported resection of a thoracic aortic aneurysm with use of such material. Lam and Aram reported such a case in 1951. Dubost and his coworkers reported resection of an abdominal aortic aneurysm in 1952. In 1951, Oudot reported on use of vascular grafts in thrombosis of the bifurcation of the aorta. This same surgeon has been mentioned by Leriche in an unpublished discussion of a paper by Lam and Aram as having resected three aortic bifurcations and having placed bifurcation homografts in the defect. Schafer and Hardin added the technique of temporarily shunting the arterial stream through polyethylene tubes to permit the occlusion during surgery of vital vascular segments such as the arch of the aorta. These authors described resection of the lower abdominal aorta for aneurysm and replacement by a homograft which remained patent; however, the patient died on the twenty-ninth postoperative day because of rupture of the aorta above the graft.

An arterial, rather than a venous, graft for replacement of a defect in the thoracic or abdominal aorta, particularly at the region of the bifurcation, would appear to be necessary because of the high pressure and large size of the vessels involved. The safety and dependability of arteries stored and frozen cannot be said to have been thoroughly tested, but results of the experimental work in the main have been more than satisfactory. Clinical experiences have of course been observed for too brief a period to give an indication of the long-term results.

The purpose of the present paper is to present further experiences with autogenous and homologous vein-graft replacement of segments of the superficial femoral artery, as well as experiences with three cases of resection of the abdominal aortic bifurcation and replacement by an arterial graft. One of these patients has been followed for nine months since surgery and will be described in detail. We have previously reported resection of lengths of the femoral artery varying from eight to thirty-eight centimeters with replacement by a vein graft. Of nineteen operations in this series autogenous grafts were used in sixteen and homologous vein grafts were used in three. The autogenous grafts were taken from the saphenous vein or superficial vein of the same extremity. The homologous vein grafts were taken from another subject by ligation and stripping of the saphenous vein performed on the same day to avoid problems of preservation.

FIG. 3-A FIG. 3-B

Fig. 3-A: Preoperative arteriogram of a man thirty-six years old.
Fig. 3-B: Postoperative arteriogram, made after insertion of a fifteen-centimeter saphenous autograft.

FIG. 4-A FIG. 4-B

Fig. 4-A: Preoperative arteriogram of a man forty-five years old.
Fig. 4-B: Arteriogram made after insertion of a fourteen-centimeter saphenous autograft

TABLE I

FOLLOW-UP ON PREVIOUSLY REPORTED SUCCESSFUL CASES

		Preoperative			Surgery	Postoperative			
		Most Distal Pulse		Arteriogram Showed Femoral Obstruction		Most Distal Pulse		Length of Follow-up (*Months*)	
Case	Age	Left	Right		Type of Graft	Left	Right		Clinical Results
1. H. H.	55	T.p.*	F.	Distal $\frac{1}{3}$, right	10-centimeter right femoral autograft	T.p.	T.p.	20	Continued relief to present.
2. P. S.	55	D.p.	F.	Distal $\frac{1}{3}$, right	8-centimeter right femoral autograft	D.p.	T.p.	18	Continued relief to present.
3. J. M.	36	T.p.	F.	Proximal $\frac{1}{2}$, right	15-centimeter right saphenous autograft	T.p.	T.p.	12	Continued relief to present.
5. S. W.	50	F.	F.	Bilateral long segments	32-centimeter right, 25-centimeter left saphenous autografts	T.p.	T.p.	17 (right) 18 (left)	Continued relief to present.
8. J. T.	51	F.	F.	Proximal $\frac{2}{3}$, left	30-centimeter left saphenous homograft	T.p.	F.	9	Pulses remain. Symptoms on right.
10. J. M.	45	T.p.	F.	Distal $\frac{1}{2}$, right	14-centimeter left saphenous autograft	T.p.	T.p.	8	Continued relief to present.
12. D. O.	55	F	None	Left long segment	25-centimeter left saphenous homograft	T.p.	T.p.	13	Relief of claudication.
					Right iliac intimectomy			6	
17. G. W.	65	D.p.	F.	Right long segment	38-centimeter right saphenous autograft	D.p.	D.p.	6	Continued relief to present.
18. A. S.	51	D.p.	F.	Distal $\frac{2}{3}$, right	25-centimeter saphenous autograft	D.p.	D.p.	7	Continued relief to present.

* The following abbreviations have been used: D.p. for dorsalis pedis; F. for femoralis; and T.p. for tibialis posterior.

FOLLOW-UP ON PREVIOUSLY REPORTED CASES

It is of interest to state at the outset that no instance has occurred among the original eighteen patients in which a demonstrated successful graft has become occluded. The longest follow-up period is twenty months and the shortest eight months. Ten grafts in nine patients have been examined for estimate of patency of the graft in the postoperative period mentioned. The results of this examination are recorded in Table I.

In two patients of the original group[12], actually the first two in whom the procedure was undertaken, an autogenous vein graft was taken from the superficial femoral vein of the same extremity. These two grafts were found to be of very large diameter compared to the diameter of the artery into which they were implanted. This was believed to be hazardous to continued patency for two reasons. First, it was feared that the artificial aneurysm might have a tendency to become larger because of some pressure relationships produced by the variation in size of the lumen. Second, it seemed that the tendency for the vein to thrombose might be increased because of the eddies and agitation of blood flow through the enlarged area within the graft. Much attention has been paid to these possibilities and the first patient (H. H., Case 1, Table I) was studied by arteriogram at the end of eleven months and at seventeen months. No change in caliber was noted. The second patient in whom a femoral vein of large diameter was implanted (P. S., Case 2, Table I) has maintained his restored distal pulsations for almost as long as the first. In this patient repeat arteriograms after three months have not been taken. Examination of the area of thigh over the graft, however, did not disclose any abnormal pulsation or bruit. This patient had a most interesting course in addition to the large size of his graft and will be mentioned again.

Three of the initial group of patients were given homologous saphenous-vein grafts. These were removed from donors by stripping and were used immediately. Two of these grafts have remained patent during the present period of study (J. T., Case 8, and D. O., Case 12, Table I) while the third was recorded as a failure because of a thrombosis immediately after operation. These patients have been watched for evidence of tissue reaction to the homologous vein, on the assumption that the first sign of such a reaction would be the disappearance of the distal pulses and an inflammatory reaction in the operative site. The possibility of an homologous-serum jaundice has also been kept in mind. Since none of these events came about, a few more direct transfers of vein grafts from donor to subject have been carried out and will be reported.

ADDITIONAL CASES OF VEIN-GRAFTING

Ten additional patients have been operated upon with six failures (Table II). In one of the six failures the graft stayed open for four months (Case 5, Table II). This increased rate of failure does not seem ominous, because of the small additional sample and because arteries which showed more advanced changes above and below the obstruction have been operated upon in the hope of improving the technique of making the anastomosis to the arteriosclerotic vessel. Seven autogenous grafts and three homologous grafts were attempted. Autogenous grafts accounted for two of the successful cases and all three of the homologous grafts were demonstrated to be open during the postoperative period. One of the latter, however, closed suddenly at the end of four months. This is the first instance in which we have observed obstruction of a graft or of an adjacent artery in which immediate restoration of pulse has been accomplished.

CAUSES OF FAILURE

There appear to be two principal causes of failure. The problem of anticoagulant therapy has been mentioned; failure in this connection may be due (1) to failure to use anticoagulant at all and (2) to the development of hematoma as a complication of heparin therapy. Hemorrhage and hematoma formation in the extensive wound required for re-

section of a large portion of the superficial femoral artery have been disturbing in their frequency. For this reason, a number of vein grafts have been placed, heparin being used as always to irrigate the regions of the anastomoses and to irrigate and flush out the graft before insertion, but postoperative use of heparin has been avoided. In those cases in which heparin has been used and hematomata have formed, only one graft has remained patent; in this case success occurred in spite of a hematoma of significant size. The development of infection in the hematoma together with subsequent hemorrhage from the proximal artery accompanied the failure in one case. Another instance of hematoma and infection was complicated by the total devitalization and necrosis of the sartorius muscle, which had evidently been devascularized excessively in the long exposure needed for resection of the femoral artery.

From our cases it is impossible to say that the best results are dependent upon the use of anticoagulants. Ideally it would seem that anticoagulants would ensure the highest percentage of good results. We believe, however, that the placing of a graft of good diameter together with the presence of good retrograde flow from the distal segment, ensuring a rapid flow of blood through the graft at the end of the procedure, is probably the most important. Needless to say there is a considerable amount of uncertainty in regard to the use of anticoagulants.

Another cause of failure has been the poor selection of cases. When the indication of essential normalcy of appearance of the arteriogram above and below the segment of obstruction has been rigidly adhered to, these procedures have been relatively dependable. If extensive disease is encountered in the arterial segment to which the anastomoses must be made, disappointment is frequent. This has occurred through failure of the arteriogram to record faithfully the extent of the disease process in the arterial segments. In such patients, it has been our practice to excise the diseased inner coat from the arterial ends in order that a non-obstructed anastomosis may be made. There is some indication that, at least for the distal anastomosis, this seriously diminishes the chance of success. It would appear that no matter how far such an endarteriectomy is carried distally, the point at which the process is stopped will represent a free edge of thickened intima, which will ride in opposition to the blood flow leaving the graft. Every tendency will be present for this free edge of intima to be undermined and to allow an intramural hematoma or dissecting aneurysm to form, obstructing the flow of blood, or for the intima to fall into the lumen and produce a valvelike obstruction. We have, therefore, tried to overcome the need for distal endarteriectomy by carefully dilating the lumen of the blood vessel with a suitable hemostat, avoiding any tear in the intima and then constructing the anastomosis of the vein graft to the thickened arterial wall, taking care to catch the innermost layer on the arterial side in every suture. As will be noted in Table II, this has not so far significantly improved our ability to use a vein graft in the more advanced cases. Such serious measures are not necessary at the proximal end, where the blood flow is in a direction which helps to hold the upper end of the endarteriectomized segment in place, rather than to produce dissection or falling into the lumen.

SEGMENTAL RESECTION OF THE AORTIC BIFURCATION

Arteriosclerotic obstruction of the aorta at its bifurcation produces the syndrome of segmental obstruction in its most prominent form. When the lesion is at this level the symptom complex has been termed the "Leriche syndrome"; it consists of the complaint of intermittent claudication, absence of femoral pulsations, and lack of significant ischaemic changes in the distal parts of the extremities. In the male the additional complaint of impotence is often present, probably because of closure of the internal spermatic arteries.

Resection of diseased areas of vessels must be followed in this location by insertion of an arterial segment comprising the aortic bifurcation. The essential data pertain to three cases in which this has been accomplished, presented in Table III. One of these

TABLE II

SUMMARY OF CASES NOT PREVIOUSLY REPORTED

Case and Age	Preoperative: Claudication	Preoperative: Most Distal Pulse Left	Preoperative: Most Distal Pulse Right	Preoperative: Arteriogram Showed Superficial Femoral Obstruction	Surgery: Source and Length	Surgery: Intimectomy	Surgery: Complications	Postoperative: Most Distal Pulse Left	Postoperative: Most Distal Pulse Right	Postoperative: Length of Follow-up (*Months*)	Postoperative: Clinical Results
F. J. 55	Bilateral after 1 block *	F.**	F.	Left	Right saphenous autograft	Proximal and distal	Anticoagulant. Hematoma.	F.	F.	10	Failure. Postoperative arteriogram showed occluded graft. Bilateral sympathectomy.
R. H. H. 39	Bilateral after 1 block	F.	F.	Right middle third	Right saphenous autograft. Spasm in spite of curare and procaine	None	None. No anticoagulant.	F.	F.	4	Failure. Immediate clot. Right sympathectomy.
W. R. J. 56	Right after 3 blocks	P.	F.	Right	Saphenous autograft	Proximal	Clotting during surgery. Anticoagulant. Hematoma. Severe hemorrhage.	P.	F.	7	Immediate failure. Secondary closure of wound. Lumbar sympathectomy.
M. J. S. 66	Bilateral after 1 block	F.	F.	Middle ⅔, left	Saphenous autograft	Proximal	None. No anticoagulant.	F.	F.	6	Failure. Left sympathectomy.

TABLE II (*Continued*)

A. S. S. 56	Right after 1 block	D.p.	F.	8-centimeter obstruction of Hunter's canal	10-centimeter homograft	None	No anticoagulant.	D.p.	F.	5	Immediate success. Closed 4 months later.
J. B. T. 60	Bilateral after 1 block	F.	F.	Right 8-centimeter block. Left.	Saphenous autograft, right	Proximal and distal	Hematoma. Anticoagulant.	F.	F.	7	Postoperative arteriogram showed open graft. Claudication after 2 blocks.
F. V. 44	Left after $\frac{1}{2}$ block	F.	D.p.	Left	Saphenous autograft	Proximal	None. Anticoagulant. Clotting during surgery.	F.	D.p.	6	Failure
E. M. 53	Right after 1 block	D.p.	F.	Left	25-centimeter saphenous homograft	None	None. Anticoagulant.	D.p.	D.p.	2	Success
***S. M. 55	Left after 1 block	F.	D.p.	6-inch block of Hunter's canal	Saphenous homograft	Proximal and distal	None. No anticoagulant.	D.p.	D.p.	1	Success
C. E. 49	Left after 2 blocks	F.	T.p.	6-inch block, middle third	Saphenous autograft	None	None. Anticoagulant.	D.p.	D.p.	4	Success

* Indicates bilateral claudication after patient has walked one block.
** The following abbreviations have been used: F. for femoralis; D.p. for dorsalis pedis; T.p. for tibialis posterior; and P. for popliteal.
*** Case included by courtesy of John T. Reynolds, M.D.

TABLE III

RESECTION OF AORTIC BIFURCATION

Case	Age and Sex	Complaints	Date of Resection	Present Pulses	Present Complaints
1. M. D.	47 Female	Bilateral thigh and calf claudication after $\frac{1}{2}$ block	March 21, 1952	Pulses to ankle on right. None on left.	Calf claudication on left after $1\frac{1}{2}$ blocks.
2. J. R.	39 Male	Bilateral thigh and calf claudication after $\frac{1}{2}$ block	September 8, 1952	Femoral and popliteal on right. None on left.	Calf claudication on left after 1 block.
3. H. B.	56 Female	Bilateral calf claudication after $\frac{1}{4}$ block	September 17, 1952	Pulses to ankle on right and left.	No claudication.

patients, who has been observed for a significant period of time, is presented in detail:

M. D. (Case 1, Table III.) A white female, forty-seven years old, was admitted to the Research and Educational Hospital of the University of Illinois on March 3, 1952. In January of 1951, this woman had had a severe upper respiratory infection. During recovery from this illness, there had been a gradual onset of severe pain in both lower extremities and the patient had had to remain in bed for several weeks. The patient had no recollection of color changes or coldness of the limbs at that time, but after a period of approximately three weeks the spontaneous rest pain had disappeared and she began to become active. At the time of admission to the Hospital, the patient was able to walk about one-half block and on every occasion it was necessary for her to stop and rest for two to three minutes because of severe cramping pain in both calves and both thighs. Claudication was also brought on routinely when she was climbing stairs, after each five or six steps. The patient did not complain of rest pain or cramps at night, nor of paraesthesia or anaesthesia.

Examination of the patient was essentially negative, except for complete absence of the femoral pulses and all pulses distal to the femoral. The skin of the feet was rather pale and cool, but had normal moisture and consistency. Venous filling time was markedly prolonged. The brachial blood pressure was 110 systolic, 70 diastolic. The past history of the patient did not indicate any cardiac condition to suggest an intracardiac source for an aortic saddle embolus. A translumbar aortogram was done, which revealed a complete block of the aorta about four centimeters above the bifurcation. In this aortogram, the collateral branches were noted to be present and were adequate to fill the external iliac arteries on both sides (Fig. 1).

On March 21, 1952, the abdominal aorta and its intrapelvic branches were exposed through a transperitoneal approach, a long left paramedial incision being used. The retroperitoneal space was exposed by reflection to the right of the sigmoid and descending colon. There was a remarkable degree of increase of fibrous tissue around the aorta, so that an attempt to free the vessel, particularly at its bifurcation, proved to be very difficult. The inferior mesenteric artery was occluded by the process within the aorta and the left colon was completely supplied by the branches of the middle colic artery. After mobilization was complete, the lower aorta and its bifurcation were removed, Pott's coarctation clamps for hemostasis being used. A graft which had been taken forty-eight hours previously at the necropsy of a twenty-year-old girl and had been stored in saline at 4 degrees centigrade was placed in the defect. Upon removal of the clamps and after completion of the anastomoses, both external iliac arteries were felt to pulsate and the right femoral and right posterior tibial pulses could be palpated. On the left, no femoral pulse was found. Postoperatively, there was considerable intestinal ileus, but the patient became ambulatory on the fourteenth day and was discharged on the twenty-eighth day.

On June 9, 1952, since the left femoral pulse had not reappeared, the left iliac vessels were explored. The left external iliac artery was opened and was found to be clear distally but blocked just below the site of the previous anastomosis. The source of improved blood supply to the left lower extremity seemed to be through the pelvic arteries from the right side entering the left iliac system through the internal iliac artery. The arteriotomy wound which had been made for exploration was therefore carefully closed, in order that this route of supply might be preserved. Palpation of the graft at the time of this operation, three months after its insertion, showed it to be of the same caliber and to be carrying a normally expansile pulse.

When she was last seen, the patient was able to walk for a distance in excess of a block, after which time she began to have pain in the left calf. The severity of the pain was less than formerly and there were no symptoms on the right.

DISCUSSION

Certain outstanding questions arise from the work presented. These have to do with comparative usefulness and safety of autogenous and homologous saphenous-vein grafts; with certain points in operative technique; with the selection of patients and an estimate of the possibility of extending the procedure to more advanced cases; and, most important of all, with the question of the over-all value of the procedure to patients in whom it succeeds.

From a technical standpoint, the implantation of a homologous graft is easier than the use of the patient's own vein. Spasm of the vein segment, which is a very troublesome feature of an autograft, is never present in the stripped-out varicose saphenous vein from another patient. Unless the recipient happens to have a varicose vein himself, better size and muscularity are provided by a homograft. The question of tissue reaction seems to be answered by the fact that of the several homografts we have implanted, only one has closed after proved initial success.

We have not yet learned whether it is best to remove the segment of obstruction or to let it remain. Ordinarily, it has been taken out as a possible source of reflex vasospastic reactions, as suggested by Leriche. When it has been left in place the results have not been definitely affected by this factor. Another technical problem has been the type of suture most suitable for these anastomoses. We have learned that an everting continuous mattress suture between a sclerotic artery and a comparatively thin-walled vein fails to provide eversion. For this reason, a simple over-and-over suture is used. Occasionally, when the vein was of exceptionally small caliber, the anastomosis was made with interrupted sutures.

Our attempts to replace the obstructed segment of an artery which showed marked changes in the non-obstructed adjacent area have usually resulted in failure. A major factor in this has been our reluctance to extend the amount of resection far enough into the patent area to reach more normal vessels, since we feared the poor result from sacrificing more collateral branches if the graft itself should fail.

The value of replacing a local obstruction in such a generalized and progressive condition lies in the fact that the most rapid method of progression available to the disease, namely, propagation of the thrombus, is removed. With rapid blood flow occurring through the artery due to the presence of the vein graft, future difficulty from arteriosclerosis can result only when some other area of the artery becomes obstructed. One demonstration of value occurred in one of the cases in the series (Case 2, Table I). In this patient, during the relatively long period of observation, the contralateral extremity, which had been the "good" limb, has markedly deteriorated, lost its pulses, and become a source of troublesome claudication, while the extremity in which the graft had been implanted continues to show strong peripheral pulses.

The replacement of the aortic bifurcation by an artery graft cannot be discussed except in the light of the question of the long-term fate of the implanted artery.

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CONGENITAL ARTERIOVENOUS FISTULAE OF THE HAND *

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The surgical treatment of congenital arteriovenous fistulae of the extremities has been extremely unsatisfactory in the past. This has been due to the very nature of the anomaly, with multiple communications between artery and vein, many of them minute. Lewis found only thirty cases of congenital arteriovenous fistulae of the extremities recorded in the literature up to 1930. In nineteen of these, surgical excision had been carried out in an attempt to close the fistula. Surgical cure could be reported in only one of these cases, while in eleven cases amputation of the extremity was necessary.

The first reported case of a congenital arteriovenous fistula of the hand appears to be that described in 1867 by Gherini of Milan, in a girl nine and one-half years old. This was treated by proximal ligation of the ulnar and radial arteries. Although it did not progress after operation, it was not cured, since the veins remained dilated. Horton and Ghormley in 1935 reported two cases of congenital arteriovenous fistulae of the hand. In one, only the index finger was involved and it was treated by amputation of that finger. In the other patient, there was involvement of the middle and ring fingers, and it was necessary to amputate both fingers as well as to perform a wedge resection of the palm for complete eradication.

ETIOLOGY

The findings of Sabin and Wollard indicate that in the embryo, arteries and veins differentiate from a common capillary plexus and that certain embryonic vessels function as arteries at one stage and as veins at another. Congenital arteriovenous fistulae result from a failure in differentiation of the common embryonic anlage into true artery and vein, and the persistence of a communication between them, producing a short-circuiting of blood. This process may persist in a limited area, such as a finger, or it may be so extensive as to involve the entire extremity.

In some instances the abnormal communications seem to reopen, becoming active shunts, after trauma to the part. While most of these arise from congenital remnants, it may be possible for such an abnormal communication to develop from the normal arteriovenous communications in the neuromyo-arterial glomus, which occur in the hand proximal to the capillary bed. Popoff, in 1934, described such an uncontrolled arteriovenous anastomosis which developed following cellulitis of a finger; the Sucquet-Hoyer canal of the glomus became inefficient as a result of the inflammatory process and acted as an arteriovenous fistula.

CLINICAL MANIFESTATIONS AND DIAGNOSIS

Varicose veins are always associated with congenital arteriovenous fistulae. One must always suspect an anomaly such as congenital arteriovenous fistula of the hand in a patient who presents himself with varicose veins of the upper extremity and a wound which fails to heal. Such a wound may follow even a trivial injury. Chronic ulceration of a finger may be followed by gangrene. The extremity or the part of an extremity that is involved may be either hypertrophied or normal in size. The skin temperature of the affected part is usually higher than that of the normal member. As a rule, neither a bruit nor a thrill can be elicited due to the small caliber of the anastomotic channels, but in some instances these channels may be large enough to produce both clinical signs. Bradycardia or a decrease in the heart rate, usually of from four to eight beats per minute, can

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 23, 1953.

sometimes be demonstrated when the artery above the site of the fistula is compressed. As a result of the shunt of arterial blood to the venous side, the oxygen saturation of the venous blood can be used as a diagnostic sign of the presence and location of the anomaly, as proposed by Veal and McCord, and postoperatively to determine if the eradication has been complete, as advocated by Horton and Ghormley. Cardiac enlargement is not, as a rule, a complication of congenital arteriovenous fistulae, due to the small caliber of the communications. However, occasionally the channels will be large enough to produce a change in the heart size as in acquired arteriovenous fistulae. The systolic and diastolic blood pressure in some instances is elevated in the involved arm when compared to the opposite normal extremity.

ARTERIOGRAM

The actual area where the communications exist and the completeness of the surgical eradication can best be demonstrated by the arteriogram.

For inspection of the arterial supply of the hand and the forearm, a small incision is made under local anaesthesia over the brachial artery in the brachium. This is done under tourniquet, by the use of the sphygmomanometer cuff which is wrapped around the arm as close to the shoulder as possible and covered with a gauze bandage to prevent ballooning when the pressure is elevated. Once the brachial artery has been exposed, the extremity is elevated for three minutes to allow complete emptying of the blood from the arteries and veins. The blood-pressure cuff is then inflated to 300 millimeters of mercury. By the use of an 18-gauge needle, thirty cubic centimeters of diodrast is injected into the artery. The first roentgenogram is made immediately after the injection. The sphygmomanometer cuff is then deflated to systolic pressure and a second roentgenogram is made. The pressure in the cuff is next deflated to diastolic pressure and a third roentgenogram is made. The last roentgenogram is made after the sphygmomanometer cuff has been deflated to zero for several pulse beats and then reinflated to systolic pressure.

The characteristic findings of the arteriogram in congenital arteriovenous fistulae as previously reported by Allen and Camp are:

1. Dilation of the arteries leading to the fistulae;

2. Absence of normal filling of the arteries distal to the fistulae;

3. Pooling of the arteriographic medium in the region of the fistulae. The pattern made by the contrast medium is suggestive of snowflakes in the region of the communications;

4. Appearance of the contrast medium in the veins distal to the point of injection in the first x-ray, while the proximal arteries are still occluded, indicates an arteriovenous fistula.

CASE REPORTS

Case 1. A man, forty-six years old, was admitted to the Union Memorial Hospital Accident Room on April 13, 1948, because of profuse spontaneous hemorrhage from a ruptured varix on the volar surface of the right hand.

He had been a carpenter since the age of fifteen, and had had no trouble with his hand. In 1934, after striking a man in the abdomen with his fist, his hand had become badly swollen, ecchymotic, and tender, particularly in the palm. The ecchymosis and pain had gradually disappeared, but the palm of the hand had remained swollen. In 1941 he first noticed the enlargement of the veins on the forearm and dorsum of the right hand and the appearance of small dilated veins on the volar surface of the ring and little fingers. In July 1945, an ulcer had developed on the tip of the little finger, which became gangrenous despite all types of treatment. On October 26, 1945, the patient had been admitted to another hospital where the gangrenous ring and little fingers had been amputated at the metacarpophalangeal joint. Postoperatively, there had been several episodes of profuse hemorrhage from the wound, which were controlled by resuturing and compression. Two attempts had been made in December 1945 to excise the abnormal communications, without success. The patient had left the hospital when amputation of the extremity was recommended. Following discharge, he had had numerous spontaneous hemorrhages as a result of ruptured varices in the amputation stump.

Physical examination was normal except for the findings in the right upper extremity. Blood pressure in the right arm was 150 systolic and 86 diastolic; in the left arm it was 124 systolic and 78 diastolic. The veins

FIG. 1-A

Case 1. A photograph made on December 7, 1948, shows the preoperative appearance of the hand with dilated veins on the dorsum of the right hand, and chronic ulceration over the amputation stumps of the fourth and fifth metacarpals, compared to the normal left hand.

FIG. 1-B

X-ray of both the right and left hands, December 7, 1948, shows decreased density of all bones of the right hand as compared to the left, and the characteristic "moth-eaten" appearance of the fourth and fifth metacarpals, right hand.

in the forearm and in the dorsum of the right hand were greatly dilated. The ring and little fingers had been amputated at the metacarpophalangeal joint (Fig. 1-A). A thrill could be palpated over the veins in the dorsum of the hand, in the hypothenar region of the palm, over the ulnar and radial arteries at the wrist, and over the deep branch of the radial artery in the cleft between the thumb and the index metacarpal. A bruit could be heard over the hypothenar area, and over the adductor space between the thumb and index metacarpal bones. This bruit was continuous in character, but it was accentuated with each heart beat, being louder in systole. The maximum surface temperature of the right hand at the wrist was 97.8 degrees Fahrenheit as compared to 96.4 degrees Fahrenheit at the same point on the left wrist. A decrease in the pulse rate of from four to six beats per minute was produced by compressing both the radial and the ulnar arteries.

On December 7, 1948, roentgenograms of the two hands (Fig. 1-B) revealed no difference in size. There were small areas of decreased density in the fourth and fifth metacarpals, producing a "moth-eaten" appearance. An arteriogram of the right forearm and hand, following the injection of thirty cubic centimeters of diodrast, showed in the first picture that most of the contrast medium was filling the veins of the forearm, having short-circuited the capillary bed by way of the abnormal communications. The major group of these abnormal channels appeared to be in the region of the hypothenar eminence, where the characteristic snowflake appearance was seen. The proximal arteries in the forearm were extremely dilated, and only in the index finger and thumb could one make out the volar digital arteries (Figs. 1-C and 1-D).

On January 31, 1949, the ulnar artery was excised with the adjacent dilated veins, including the abnormal communications from the lower third of the forearm. This excision extended into the palm with a block excision of the skin, the fifth metacarpal, and the hypothenar muscles, and the superficial volar arch, with excision and ligation of all vessels in this area. Care was taken to preserve the volar arteries to the index and middle fingers and thumb, the volar digital nerves, and the motor branch of the ulnar nerve (Fig. 1-E).

Microscopic examination of excised tissue showed thinning of the arterial wall, with hypertrophy and dilatation of veins.

FIG. 1-C FIG. 1-D

Arteriograms, December 7, 1948.

Fig. 1-C: Shows enlarged tortuous ulnar artery injected, and the characteristic puddling of diodrast, primarily in the hypothenar area, with numerous veins visible on the ulnar aspect of the hand in the first x-ray.

Fig. 1-D: Shows enlarged and tortuous radial artery injected. No digital vessels can be visualized in the middle or index fingers, or in the thumb.

Postoperatively, examination revealed a thrill and bruit still present over the radial artery in the adductor space between the thumb and index metacarpal bones. On February 25, 1949, the radial artery and an adjacent dilated vein were excised, and several communicating vessels from the radial artery to adjacent veins were ligated. The radial artery excision extended to the point where the deep branch of the radial artery passed into the palm at the border of the short adductor muscle. Since June 1949, the patient has been working as a carpenter, using the right hand for all types of heavy work and hammering. An arteriogram on November 18, 1952, (Fig. 1-F) revealed no evidence of any venous filling, and diodrast could be seen entering the volar digital arteries of the index finger. At this time the interosseus tendons to the middle finger were tenotomized, and the terminal phalanx of the middle finger was amputated to allow flexion at the proximal interphalangeal joint, which had been held in rigid extension by the shortened interosseus muscles to the middle finger.

Case 2. A woman, fifty-two years old, was seen on November 11, 1950, because of pain and discoloration of the tip of the right middle finger.

In 1930 the patient had burned the right hand and the right middle finger had become secondarily infected following the burn. She stated that in 1945 some swelling of the right middle finger first appeared. In April 1949, the skin over the volar aspect of the terminal phalanx began to split and a small fissure developed, which was painful and

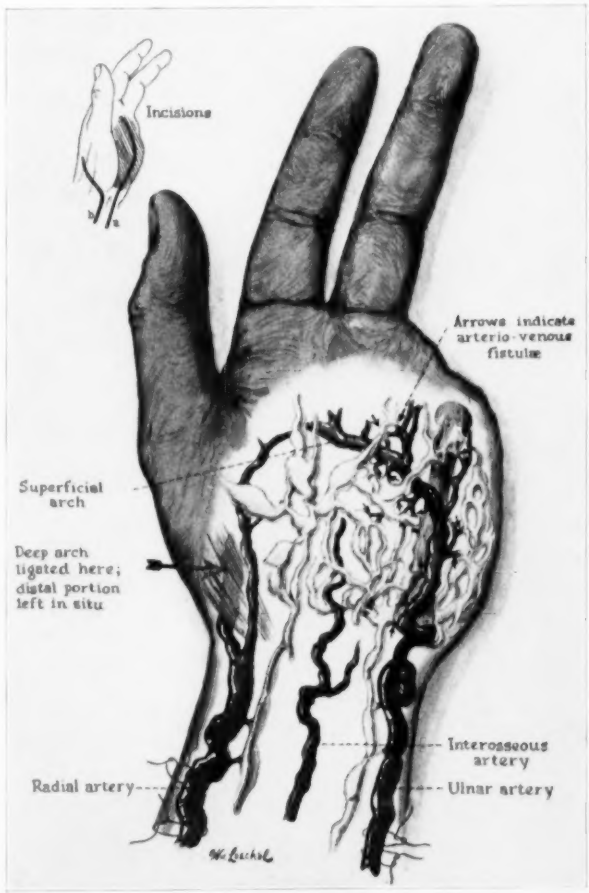

Fig. 1-E

Fig. 1-E: Schematic diagram showing relative positions of the arteriovenous communications and the sites of ligation and excision of ulnar arteries in procedure A, and of radial artery in procedure B. (Drawing is of a left hand, but Case 1 involved the right hand.)

Fig. 1-F: Arteriogram made November 18, 1952. Digital arteries in the index finger and the thumb are visible. The vascular supply to the hand and fingers is maintained by a greatly dilated interosseous artery arising from the ulnar artery. There is no venous filling, but there is some suggestion of puddling of diodrast in the region of the carpal bones.

Fig. 1-F

FIG. 2-A

FIG. 2-B

FIG. 2-C

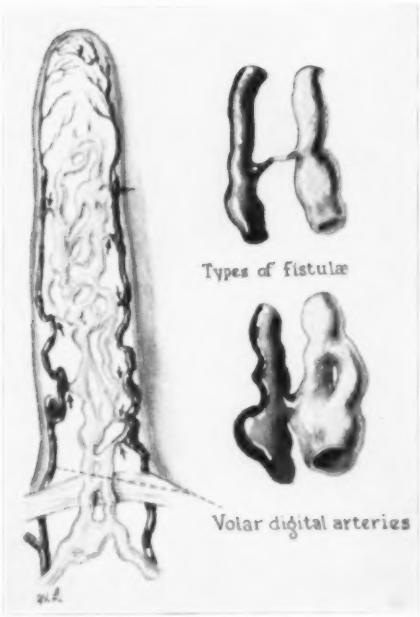

FIG. 2-D

Fig. 2-A: Case 2. This photograph, made on December 21, 1950, shows discoloration over the terminal phalanx, with an atrophic fingernail and tip of the finger, and dilated veins over base of finger.

Fig. 2-B: A preoperative arteriogram made on December 21, 1950. The arterial tree is well outlined. Puddling of the diodrast in the region of the proximal interphalangeal joint points out the area of arteriovenous communications. Some of the veins in this region are filled on this first x-ray.

Fig. 2-C: The amputation stump in September 1952.

Fig. 2-D: A schematic diagram showing the sites of the fistulae and the types of communications found.

would not heal. The skin at the base of the fingernail had been opened several times by a local doctor because of a suspicion of paronychia, but only blood was obtained.

Physical examination showed no abnormality except in the right hand where, over the dorsum of the right middle finger, there were numerous dilated and engorged veins. At the base of the fingernail and over the tip of the finger there was an area of extreme redness, almost inflammatory in nature (Fig. 2-A). This was found to be due to dilated venous sinuses filled with oxygenated arterial blood. No thrill or bruit could be

Fig. 3-A: Case 3. A photograph made August 5, 1952, shows chronic ulceration of the right thumb.

Fig. 3-B: Dilated veins of the dorsum and base of the thumb before operation.

Fig. 3-C: An arteriogram made August 5, 1952, shows good arterial tree but no filling of the digital arteries of the thumb, or of the radial side of the index finger. The area of arteriovenous communications is characterized by puddling of diodrast in the thenar area and over the metacarpal bone of the thumb. One large vein can be seen filled with diodrast in the x-ray shown on the radial side of wrist and forearm.

Fig. 3-D: An arteriogram made on December 8, 1952, shows some puddling of diodrast over the proximal phalanx of the thumb. One vein on the dorsum of the thumb can be seen filled with diodrast in the x-ray shown.

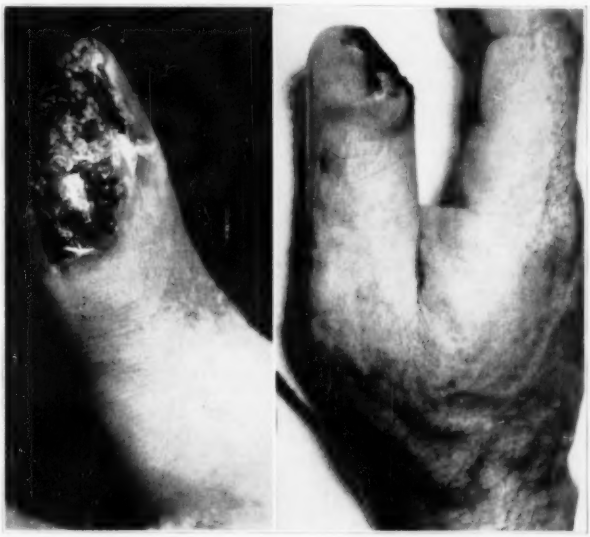

FIG. 3-A

FIG. 3-B

FIG. 3-C

FIG. 3-D

definitely made out. The finger felt spongy throughout and appeared larger in diameter than the left middle finger, although they were equal in length.

On December 21, 1950, an arteriogram was made after twenty cubic centimeters of diodrast had been injected into the right brachial artery. The first roentgenogram revealed that the arterial tree was well outlined in the hand and fingers, with the exception of the middle finger, where no contrast medium could be seen to enter the distal part. The venous system of the middle finger, however, was well outlined, with an area of puddling over the middle phalanx, which showed the characteristic snowflake appearance (Fig. 2-B).

A teleoroentgenogram of the chest revealed the heart to be of normal size.

On December 22, 1950, an incision was made on the radial side of the left middle finger from base to tip, and six dilated tortuous communications were seen. The artery and vein with their abnormal communications were excised. On May 25, 1951, because of persistent complaints of pain and poor healing at the tip of the finger, the finger was re-explored on the radial and the ulnar aspects from base to tip, and the volar artery and vein on the ulnar side of the finger were excised, with several abnormal communications (Fig. 2-D).

Microscopic sections of the excised tissue presented cross sections of both arteries and veins. The lumen of the artery was greatly distorted, and there was variation in the thickness of the wall with interruptions particularly in the media. Organized and recanalized thrombi were seen forming part of the intima. The vein was tortuous and dilated with some fibrosis. The patient continued to have pain and on June 13, 1952, the finger was amputated through the proximal phalanx. The patient has had no symptoms in the hand since this operation (Fig. 2-C).

CASE 3*. A man, thirty-one years old, was admitted to Veterans Hospital, Fort Howard, Maryland, on May 1, 1952, complaining of a painful chronic ulceration on the tip of the right thumb.

In April 1952, while loading lumber onto a truck, the patient had a splinter enter the tip of the right thumb. The next day he was seen by a local doctor who treated him with intramuscular penicillin and soaks of boric acid solution because the thumb had become infected. Within a few days an area of gangrene developed about the

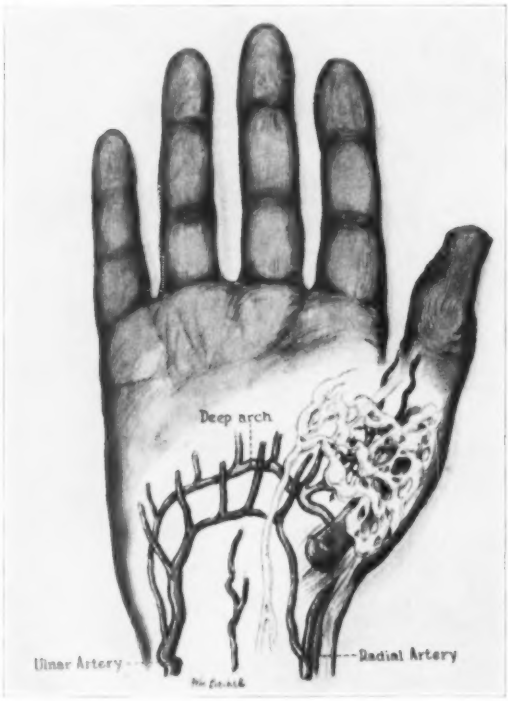

FIG. 3-E

FIG. 3-F

Fig. 3-E: A schematic diagram showing the relative positions of the arteriovenous communications found at the first operation, August 14, 1952.

Fig. 3-F: This photograph, made on December 8, 1952, shows ulceration healed.

* Case report from the Veterans Administration Hospital, Fort Howard, Maryland. Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the author are the result of his own study and do not reflect the opinion or policy of the Veterans Administration.

wound, which gradually sloughed, leaving a large ulcer involving most of the volar surface of the terminal phalanx of the thumb.

Physical examination was essentially negative except for the findings in the right hand. There was a large ulcerating wound on the volar surface of the right thumb (Fig. 3-A). Numerous dilated veins were visible on the dorsum of the thumb, in the adductor cleft between the thumb and index metacarpal bones, and on the thenar area of the palm. No thrill or bruit could be made out.

On August 5, 1952, thirty cubic centimeters of diodrast were injected in the brachial artery and an arteriogram of the right hand revealed the arterial tree well outlined in the hand and all the fingers. In the thenar area there was puddling of the diodrast in the characteristic snowflake pattern and in the first x-ray a large superficial vein along the radial side of the forearm was filled with diodrast. The volar digital arteries of the thumb did not fill (Fig. 3-C). The terminal phalanx of the thumb had the characteristic "moth-eaten" appearance in the roentgenogram. Teleoroentgenograms showed no cardiac enlargement.

On August 14, 1952, the superficial branch of the radial artery was ligated and the following were excised: the skin of the thenar area of the palm and of the flexor surface of the thumb, the volar digital arteries of the thumb and all vascular structures in this area, including numerous arteriovenous communications (Fig. 3-E). The thenar muscles, the long thumb flexor tendon, and the volar digital nerves were preserved intact. The denuded area was then covered with a thick dermatome skin graft. The ulceration of the thumb healed slowly.

Following operation, an arteriogram was made on December 8, 1952, and the first x-ray revealed that there was still an area of puddling with snowflake appearance over the proximal phalanx of the thumb, and that one vein on the dorsum of the thumb had filled (Fig. 3-D). Clinical examination showed that there were still some dilated veins on the dorsum of the thumb, connected with one dilated vein on the flexor surface of the forearm.

This patient was readmitted for operation on March 3, 1953, at which time the remaining abnormal communications on the dorsum of the thumb were excised by removal of a dilated and tortuous dorsal artery and adjacent veins, together with numerous abnormal communicating vessels. The incision healed readily and the patient returned to work as a laborer. The dilated vein on the volar surface of the forearm has diminished in size.

CONCLUSIONS

Multiple arteriovenous communications in the hand usually have their origin in congenital remnants of the embryonic anlage of the arteries and veins. However, such abnormal communications may also develop from the normal arteriovenous communications which occur in the hand and are known as the neuromyo-arterial glomus. In this event, this structure apparently becomes uncontrolled as a result of damage. In one of the three cases reported here, arteriovenous fistulae developed in a finger after a burn became infected. This may be an example of the latter type of pathogenesis.

The diagnosis of congenital arteriovenous fistulae is best made by the arteriogram, since it shows the site of the abnormal communications. The operative procedures for the eradication of these minute anastomotic channels must accomplish this end with the least possible sacrifice of the function of the hand. The excision must be staged, in some instances, to allow adequate collateral circulation to develop between stages. Excision of the skin overlying the lesions, with replacement by pedicle or other types of skin graft, may be necessary in order to excise all communications. The operations are best carried out under tourniquet. A postoperative arteriogram provides the best evidence of adequate excision.

There was no indication in the three cases reported that surgical intervention caused the process to extend into areas where a normal vascular tree existed. One case has been followed for four years without evidence of recurrence.

Excruciating pain in an area of ulceration was a constant finding in the three patients and this was not relieved until healing had occurred.

Although it may not be possible to eradicate every one of the tiny arteriovenous communications in a given patient, in most instances where the process is localized they can be eradicated sufficiently to allow healing to take place and to prevent progressive gangrene and loss of function of the hand.

It is of utmost importance to recognize the clinical entity early and to institute radical surgical treatment before the process causes irreversible changes in the extremity.

In one of the patients described, such an irreversible change had taken place and an amputation of the involved finger was necessary. In the other two cases, adequate excision preserved the remaining hand function.

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DISCUSSION

Dr. George V. Webster, Pasadena, California: Dr. Curtis' paper and accompanying illustrations cover a subject which is of considerable interest, although the condition is relatively infrequent. The paucity of reports in the literature is a little deceptive, however, as several such cases in a period of a few years have occurred in my limited personal experience. Similar unrecorded cases are undoubtedly the experience of other surgeons interested in this field of surgical pathology.

In his paper, Dr. Curtis scarcely emphasizes the correlation between congenital arteriovenous fistula and hemangioma of the upper extremity. In most cases, these fistulae first appear as hemangiomata of the cavernous type. An example of this is a recent case of ours, a child six months of age, who, after birth, had a slight redness over the distal head of the radius. This increased to a definite capillary type of hemangioma within three to four weeks and was treated by a dermatologist by the application of carbon-dioxide snow without effect, except for scarring of the skin surface. The lesion progressed to a rapidly growing cavernous type of hemangioma covering much of the distal third of the forearm during the next few months of life. When first seen at six months of age, the child showed definite evidence of congenital arteriovenous fistulae. Other lesions, occurring in middle life, undoubtedly have their origin, as Dr. Curtis points out, in the common embryonic capillary plexus, but they are indistinguishable from small cavernous hemangiomata.

Geschickter and Keasby [a] in a review of 570 cavernous hemangiomata showed that forty (or 7 per cent.) of them occurred in the hand and forearm. Chamberlain and Pendergrass [b] in 1948 stated that approximately 5 per cent. of cavernous hemangiomata occur in the hand.

Early recognition and treatment of cavernous hemangiomata will prevent some later arteriovenous channels from developing. In this connection, one should caution against the use of x-ray and radium therapy because of the effect on the epiphyses and growth. Moreover, the atrophy of the skin and subcutaneous structures, following such treatment, is at times crippling and disastrous. In one instance, an epithelioma was seen to have arisen in the irradiated scarred area on the arm in a female patient twenty-three years of age following treatment of a cavernous hemangioma in infancy. Watson and McCarthy [c] in 1940 stated that "With the exception of superficial capillary lesions and large inaccessible tumors, application of sodium morrhuate is the method of choice for treatment of cavernous hemangiomas at Memorial Hospital. This solution has been used with increasing frequency since it was first imported in 1935." Certainly sclerosing therapy or surgery or both are indicated in the larger lesions. Elkin and Cooper [d] in 1947 stated that hemorrhage, malignant degeneration, and progression to cirsoid aneurysms are further indications for radical extirpation of such cavernous hemangiomata. In their series of nineteen cases, two were in the hand.

In the diagnosis of arteriovenous fistulae, clinical signs, such as elevated skin temperature, which Dr. Curtis has mentioned, and an occasional slight bruit are usually present. Cardiac enlargement and failure occur in the late cases and are definite complications of arteriovenous fistulae, as shown so beautifully in the monograph of Emile Holman [e] in 1937. The differential of blood-pressure readings in the two arms is a most constant finding in advanced cases.

Differences in bone length, while not demonstrated in Dr. Curtis' cases, are nicely shown in a recent case cared for by Dr. Thomas W. Stevenson and myself, in which the bone length, as measured on the x-ray

films, showed an increase in length of the ulna of one centimeter on the affected side and of 1.5 centimeters of the radius on the affected side. This was in a forty-year-old woman who had had a congenital cavernous hemangioma of the index finger and later an arteriovenous fistula. Since these measurements are from long bones, and the difference is relatively small, it would be necessary to do bone-length studies on the entire upper extremity to determine significant difference in length in most cases.

While the arteriograms presented by Dr. Curtis are all that one could wish, I can scarcely agree that this is a necessary diagnostic procedure in every case. It is of more academic value for follow-up studies to provide an index of the adequacy of excision. Even then, clinical observations, and especially the comparative blood-pressure readings, provide an almost equally good clinical study without the arteriogram which is not without some risk, however slight.

In conclusion, we would certainly agree with the indications and recommendations of Dr. Curtis but would like to call attention to the point that, where arteriovenous communications extend within the marrow cavity of the long bones, whether in finger, forearm, or humerus, amputation of the affected long bone is the only curative treatment.

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Dr. Thomas W. Stevenson, New York, N. Y.: It is a pleasure to discuss the paper presented by Dr. Curtis. Fortunately, arteriovenous fistulae are infrequent. A good plan of attack has been outlined by Dr. Curtis. The arteriograms which he has shown have been beautifully executed and should be an example for us both in diagnosis and in testing the efficacy of the excision. The author states that "it is possible to excise congenital arteriovenous fistulae"; but in my opinion a satisfactory outcome is rarely possible. In such an evaluation, simple angiomata, amenable to injection, as mentioned by Dr. Webster in his discussion, should be ruled out. The blood-pressure and flow rate are so high in the presence of multiple fistulae that satisfactory thrombosis cannot be obtained by sclerosing therapy. Indeed, this is the main cause for most of the symptoms produced by this lesion, — namely, dilated and sometimes pulsating veins leading from the lesion, increased heat, chronic ulceration, hypertrophy or enlargement of the part, bruit and thrill, active pulsation and spontaneous or post-traumatic hemorrhage. Sometimes the arteriovenous communications act as shunts, so that there is absence of normal filling of the arteries distal to the fistula. This relative ischaemia may diminish the growth of the part and occasionally predispose to actual gangrene. In general, it appears that a lesion with a single fistula is relatively easy to correct, but difficulty in treatment increases with the number of communications and, if bone is involved, cure without amputation is practically unknown. I wish to present briefly three illustrative cases.

Case 1. G. D., a woman forty-two years old, had had swelling and discoloration of her right index finger with distended veins on the dorsum of the hand for as long as she could remember. In 1951, she had an extensive excision and multiple ligation well performed by Dr. George V. Webster. The finger remained stiff, semiflexed, dusky, and painful. One month after her last operation she was seen in Chicago with Dr. Webster. There was a black area at the finger tip measuring 1 by 1.4 centimeters, extending beneath the nail. The skin was dry and hard. There were dilated veins present on the ulnar side of the dorsum of the finger, but no pulsation. Amputation was recommended. One month later, there were pulsations present on each side of the base of the finger. The patient again refused to consider amputation. In August 1951, there still remained attached dry necrosis of skin, fat, and bone. The veins were more distended. There was a large pulsating vessel on the ulnar side of the dorsum of the hand. Motion of the other fingers was limited. In October 1951, she was seen with Dr. Webster and Dr. Joseph H. Boyes and again amputation was recommended. On December 7, 1951, the tip was healed except for a 3 by 3 millimeter bone spicule beneath the nail. The patient was unable to use the finger and discomfort was great. In June 1952, diodrast injection was done by Dr. Arthur H. Blakemore. There was a small hematoma in the arm and further embarrassment of circulation of the finger. On July 24, 1952, the finger was amputated through the base of the second metacarpal. Pathological examination seemed to indicate that all of the fistulous area was in the distal portion of the finger. There were multiple, minute arteriovenous communications. The patient's condition so far has been satisfactory.

Case 2. H. U., a woman thirty-one years old, showed the type of lesion that is readily amenable to surgical excision. She fell and injured her right hand at the age of eleven years. There was no open wound. When she was sixteen, an operation was performed with a diagnosis of hemangioma. Increased dilation of veins was noted postoperatively, and prior to the time of excision on September 28, 1943, a black spot ap-

peared at the base of the thumb, and soon a hemorrhage occurred from this area. There were dilated veins up the forearm and no radial pulse was felt below the old operative scar. The ulnar artery was unusually large and there was active pulsation in the palm. A single fistulous communication was found and complete excision was readily carried out with no serious impairment of other structures.

Case 3. J. C., a four-year-old child, had an extensive hemangioma involving most of the right arm from the elbow down, which had been treated with radium since birth. There had developed ulnar deviation of the hand, more marked during the past year, and there had been profuse bleeding for about four days from the region of the wrist. The arm was greatly enlarged. Pulsations were visible in the arm and shoulder with active thrill and bruit. X-rays showed the humerus and radius longer than on the left, but the ulna was shorter. During 1947, 1948, and 1949, six major operations were performed for ligation of communicating vessels, starting with the subclavian ligation. There were multiple scars mostly situated just above the elbow. The total of these scars completely encircled the arm. An increase in ulceration of the forearm followed the last ligation and active hemorrhage took place. The parents would not consent to amputation. The brawny, scarred, hemorrhagic angioma on the flexor surface of the forearm was excised including subcutaneous tissue. Large venous spaces and large thick-walled arteries were noted passing in all directions through muscles, aponeurotic layers, and surrounding tendons. The largest of these vessels measured 6 to 8 millimeters in diameter. Despite this unfavorable bed for a graft, a partial-thickness graft was applied with the tourniquet still in place. A firm, constricting bandage was applied. Fortunately, a good take was obtained; however, in the ensuing months, numerous areas of capillary hemangioma appeared in the graft. Ulceration again developed near the radial styloid and hemorrhage occurred. By this time, the family had been sufficiently impressed by the hazard of repeated hemorrhage to consent to amputation, which was done in the supracondylar region. Extensive involvement was found in all of the tissues of the forearm and wrist. The finger tips had remained diminutive and the ulnar styloid had not developed fully, probably as a result of the by-passing of the normal blood flow. This is the type of case in which cure by surgery without amputation is inconceivable.

I wish to thank the author for permitting me to discuss his paper. I agree with him entirely that a careful analysis of the case is essential and a well worked out, staged plan of attack is indicated. It is likely that an attempt at local excision would be indicated in most cases before reaching the conclusion that amputation offers the only sure cure.

Dr. Curtis (closing): I want to thank Dr. Webster and Dr. Stevenson for their comments, many of which have more broadly emphasized some of the problems that occur in this particular entity.

As Dr. Webster points out, it is important to remember that arteriovenous fistulae can occur in cavernous hemangioma. Dr. Mont Reid, in discussing arteriovenous fistulae, felt that we should group together pulsating aneurysm, cirsoid aneurysm, and simple angioma as all having arteriovenous communications.

I should prefer not to use sodium morrhuate in the hand to obliterate these abnormal vascular channels for fear of producing necrosis and gangrene of functioning parts.

Dr. Webster advocates amputation where the arteriovenous communications involve bone. This may be necessary, as for example, in the tibia. However, if the thumb metacarpal were so involved, I would attempt excision of the metacarpal and replacement with a bone graft.

As to the arteriogram, Dr. Stevenson has pointed out some of its limitations. However, I think it is important to recognize this clinical entity early and to do the arteriogram early. In our Case 1 the initial operator had failed to eradicate the process, because a preoperative arteriogram had not been done, and the extent of the lesion had not been determined. In our Case 3 the arteriogram after operation indicates incomplete eradication of the process.

I want to re-emphasize the role which trauma may play. Before leaving Baltimore, I saw a patient who had had no trouble whatsoever with his hand until one year previously when he dropped a heavy metal plate on the thenar area and had some swelling afterward. At the present time the findings are consistent with an angioma with arteriovenous communications of the thenar area. We may have to revise our opinion that all multiple arteriovenous fistulae arise from congenital defects. I think it is more than a happenstance that they occur in the thenar and hypothenar area and in the fingers where we know there are numerous arteriovenous shunts which can be damaged by trauma and become uncontrollable. I should like to emphasize the necessity for adequate pressure dressings and splinting to the contused hand as measures which may prevent the development of arteriovenous fistulae in the normal neuromyo-arterial glomus.

NYLON MEMBRANE ARTHROPLASTY OF THE KNEE IN CHRONIC ARTHRITIS*

BY JOHN G. KUHNS, M.D., THEODORE A. POTTER, M.D., ROBERT S. HORMELL, M.D., AND WILLIAM A. ELLISTON, M.D., BOSTON, MASSACHUSETTS

From the Robert B. Brigham Hospital, Boston

Arthroplasty of the knee offers unusual problems in chronic arthritis. Many arthroplastic procedures[14] have been described since the first report by Verneuil in 1860, but few successful arthroplasties of the knee have been observed in patients with chronic arthritis[18]. The reasons for this were the uncertain activity of the disease, the unpredictable future course, and the serious involvement of all supportive tissues. Fascia lata, often used between the articular surfaces, wore away readily in weight-bearing joints[13]. Prior to 1940 our results from arthroplasty of the knee in chronic arthritis were poor, showing in all cases re-ankylosis or only a few degrees of motion. For this reason we sought more durable materials to place between the reshaped articular surfaces. Attempts to use metallic onlays resulted in failure. Malleable, non-oxidizable metallic sheets were unsuccessful in our hands.

In animal experiments, thin sheets of various plastics produced little fibrous-tissue stimulation and there was none whatever from nylon membrane[10]. Nylon is the trade name of a plastic used in making strong, durable threads. Nylon membrane is made from powder rolled under pressure into sheets from .003 to .005 inch in thickness. Nylon is melted by heat, is resistant to chemicals, and does not absorb water[9]. Hypersensitiveness to nylon has been reported[7], but we have not found hypersensitiveness in any of our patients. This nylon membrane has been used during the past nine years in seventy-seven arthroplasties of the knee for patients with chronic arthritis. Seventy of these have been followed for six months or longer and are included in this study.

The indications for arthroplasty of the knee are not sharply defined. In chronic arthritis, while it is conceded that ankylosis of both knees is a severe handicap, ankylosis or limitation of motion in one knee is rarely a serious disability. In chronic arthritis rarely is one joint alone involved; usually there is serious involvement of many joints. At the present time we believe that arthroplasty of the knee is indicated in chronic arthritis when ankylosis of both knees is present. If the hips are ankylosed also, they should be made moveable before operation upon the knees is contemplated. In knee joints, when the articular cartilage has been destroyed and there is constant pain and disability, arthroplasty is the procedure of choice. In osteo-arthritis, when the knee joint shows severe incongruence, when osteo-arthritis is present in both knees, and when prolonged conservative treatment has failed, arthroplasty can produce a useful, painless knee[11]. Since our work was carried out in a hospital devoted to the treatment of chronic arthritis, we cannot offer indications for treatment in infectious or traumatic arthritis.

Among the contra-indications the first is the presence of active arthritis. The arthritis should have been clinically inactive for at least a year before arthroplasty is attempted. Poor general health which makes arthroplasty hazardous is a contra-indication. If more than one joint in the extremity is ankylosed, the more proximal joint should be operated upon first, since stiff proximal joints will interfere with the postoperative mobilization of more distal ones. In children with juvenile rheumatoid arthritis and ankylosis of joints, arthroplasty should be delayed until after the epiphyses have closed. The surgical reshaping of the articular surfaces in children will destroy proliferating cartilage and will lead to shortening of the limb.

For the arthroplasty, the knee is exposed by a long medial parapatellar incision. The

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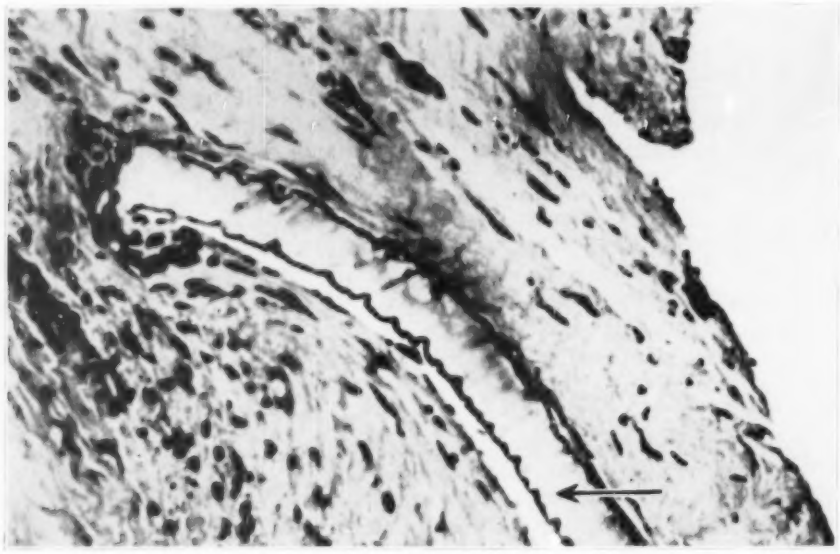

FIG. 1

Nylon at edge of joint (see arrow). There is no reaction to the nylon membrane.

deep fascia and the articular capsule are incised. Often a real articular cavity cannot be identified. The patella must usually be separated from the femur and the femur from the tibia. The tibial and fibular collateral ligaments are spared to preserve lateral stability. The knee joint is flexed and the intra-articular ligaments and the semilunar cartilages are removed. These intra-articular structures are always degenerated in the arthritic knee joints. After the cruciate ligaments have been cut, the flexed tibia can be pushed forward upon the femur without difficulty. A shallow transverse groove is cut in the tibial plateau. The lower end of the femur is fashioned into a shallow wedge to fit the lower end of the tibia [8]. About one-half inch of the articular surface is resected [17]. At least one half of the thickness of the patella is sawed away and a thin coinlike bone remains. The knee is then extended so that the fit of the newly formed joint may be observed. Rough surfaces are smoothed with a rasp.

When the articular surfaces have been reshaped satisfactorily, the nylon membrane is attached over the femoral condyles and the supracondylar area [4]. The nylon membrane is sterilized by soaking it in aqueous zephiran chloride overnight. It is placed in cold normal saline for at least an hour before operation in order that the antiseptic solution may be removed as completely as possible. The nylon is first attached to the posterior aspect of the femoral condyles. In the patients first operated upon, the nylon membrane

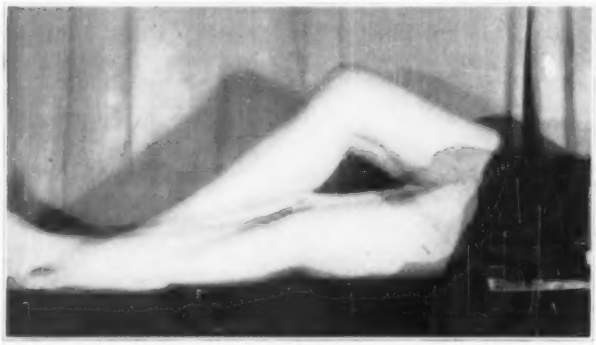

FIG. 2

Composite picture of flexion and extension of left knee. There is 80 degrees of active motion.

FIG. 3-A

FIG. 3-B

Fig. 3-A: X-ray of knee showing fibrous ankylosis and destruction of joint.
Fig. 3-B: After nylon arthroplasty the joint surfaces have been reshaped. Nylon has been stapled over the femoral condyles.

was attached to the bone or periosteum with nylon or silk thread. In those operated upon during the past two years, a firmer attachment and a smoother surface have been obtained by using small stainless-steel staples which are driven into the bone. Neither staples nor stitches are attached on the weight-bearing surface of the joint. Any pleats that are required are kept outside the weight-bearing surface.

Bleeding is controlled by electrocautery. No tourniquet is used. The joint should be relatively dry when it is closed. In the first six patients the knee joint was ankylosed in full extension, and the quadriceps tendon was lengthened after the method of Bennett to secure flexion. While satisfactory function was obtained in five of these knees, further experience has shown that this procedure is required only in rare instances. The resection of the articular surfaces and persistent physical therapy after operation usually permit full extension and adequate flexion. The authors believe that better function results when the patella is not completely removed [15].

After operation the extremity is placed in slight flexion in a well padded plaster cast. Blood loss is replaced as necessary, and penicillin is given as a prophylactic measure for several days. The cast is usually bivalved in five days and muscle-setting exercises are begun on the limb muscles. Motion against gravity is started after the skin wound has healed. Partial weight-bearing is permitted with a bivalved plaster cast in three weeks unless there is much bone atrophy. It requires about six months to obtain good function in the knee joint and adequate strength in the muscles of the thigh [6]. After healing of the wound, there is usually no swelling, tenderness, or local heat. The knee operated upon feels the same as the other knee on motion. Fluid aspirated from these joints after healing

TABLE I

COMPLICATIONS

Type	No.	Persisting
Limitation of flexion to less than 60 degrees	14	4
Pain on motion	10	4
Hemarthrosis	3	0
Bony overgrowth about joint	3	2
Exacerbation of arthritis	3	0
Infection of wound	3	0
Slough of tissues	2	0
Re-ankylosis	2	2
Phlebitis	1	0
	41	12

is indistinguishable from normal synovial fluid. No late deterioration in function has been observed. Complications, if they appear, are evident in the early months of convalescence.

The usual complications observed were persistent limitation of flexion, pain on motion, hematoma, bony overgrowth, infection, and exacerbation of the arthritis[10]. Less common were slough of the wound, re-ankylosis, and phlebitis (Table I). In fourteen patients there was limitation of flexion, which had not reached 60 degrees in three months[12]. In six of these patients, there was sufficient improvement after manipulation under anaesthesia. In three patients the extremely resistant quadriceps muscle was lengthened and this subsequently permitted adequate flexion. In the remainder of the patients the only treatment was vigorous physical therapy. All have improved, but four of these have not achieved 60 degrees of active flexion.

Pain on motion persisted after healing of the wound in ten patients. In most of these, a mechanical cause of the pain was suggested by swelling, effusion, or locking of the knee. In six of these patients, arthrotomy showed loosening of the nylon at one corner with subsequent rolling and impingement between the articular surfaces. After four months the nylon was removed and at operation the articular surfaces were found to be covered with smooth fibrous tissue. In these patients, removal of the nylon led to subsidence of pain and other symptoms. These patients now have good function. In the remaining four, while pain has not entirely disappeared, improvement has occurred under physical therapy and the patients do not wish further surgery.

In three patients, hemarthrosis developed during the first twenty-four hours after operation. Pressure bandaging postoperatively usually prevents this complication. In these patients the hemarthrosis was relieved by aspiration and the reapplication of a pressure bandage. The puncturing of the upper portion of the quadriceps pouch, as suggested by Chandler, is a helpful measure in the prevention of the development of postoperative effusions in the articular cavity. Hemarthrosis did not jeopardize the end result in these cases.

In three patients, bony spurs developed about the margins of the joint. In one of these, operative removal of the bony overgrowth led to improved function, which has persisted. In the other two the restriction of motion persists and operation has been advised.

No serious infection occurred in any patient. There were three infections in the wounds by organisms of low pathogenicity which were not controlled by the antibiotic therapy. These wounds healed slowly, but the knees now have good function. There was an exacerbation of the arthritis within four months of the operation in three patients, but no involvement at the knee operated upon. A recurrence of active arthritis is a constant threat in rheumatoid arthritis, particularly after major surgical procedures. It can be avoided in most instances by delaying surgery until the arthritis is clinically inactive and until the general condition of the patient is satisfactory.

In two patients re-ankylosis of the knee occurred. In one of them, ankylosis had originally followed arthritis in childhood, twenty years before. The extensor muscles of the knee were almost completely replaced by fibrous tissue. Severe necrosis of this extensor apparatus followed operation. The nylon was removed early and the knee was permitted to ankylose. In the other patient fibrous ankylosis developed about the edges of the condyles, and progressed to bony fusion. The patient is able to work, but another attempt to produce a moveable knee is contemplated.

A slough of the skin and superficial fascia occurred in two patients. These required small skin grafts, with a delay in convalescence, but no final impairment of function. In one patient forty-eight years old, a severe phlebitis occurred two months after operation while the patient was convalescing in another hospital. This delayed physical therapy for six months. Recovery of flexion was slow, but the patient now has 60 degrees of active flexion from full extension, and the range of motion is slowly increasing. Most of these complications can be avoided, or at least made less severe, by careful preoperative and postoperative care and by skillful physical therapy.

In the table of end results (Table II) we have divided the patients into those with bony ankylosis, those with destruction of

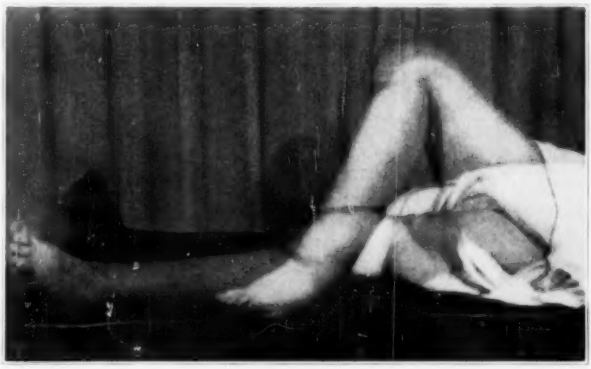

FIG. 4

Severe osteo-arthritis of left knee with dislocation of patella. Scar of two previous operative attempts for correction of displacement of patella below knee.

FIG. 5-A

Severe osteo-arthritis before operation.

FIG. 5-B

Removal of overgrowth with nylon arthroplasty.

TABLE II

END RESULTS

Condition	Good	Unsatisfactory
Destruction of joint with pain and disability	33	5
Bony ankylosis	15	3
Osteo-arthritis	8	2
Suppurative arthritis	2	2
	58	12

the knee joint with pain and disability, those with osteo-arthritis, and those with suppurative arthritis. We do not know when the result of an arthroplasty of the knee can be regarded as an end result; improvement continues for a long time. Although good function is usually secured in six months, when physical therapy is delayed by various causes, improvement may continue for as long a period as two years. It has been stated that 60 to 70 degrees of painless motion with a stable knee is the most desirable function after arthroplasty of the knee[1, 2, 3]. With the newer, more vigorous physiotherapeutic techniques, more motion is frequently obtained. Twenty-six knees have 90 or more degrees of active motion. We have called satisfactory those knees which have 60 or more degrees of active motion from extension without pain and with a stable knee joint. All others we have placed in the unsatisfactory class, although such patients are all bearing weight on these knee joints.

DISCUSSION

No type of arthroplasty produces a normal joint. We believe with Allison and Brooks that the ideal substance for interposition in arthroplasty of the knee would be an absorbable material which would cause no irritation and which would persist until the active production of granulation tissue had ceased. A material of this type still awaits discovery. Up to the present, nylon membrane has proved to be the most satisfactory material for arthroplasty of the knee in chronic arthritis. The amount of active motion obtained is largely dependent upon good postoperative physical therapy. It is hoped that at least half of the cases now listed as unsatisfactory may be salvaged by the assiduous use of physiotherapeutic procedures.

It has been stated that equally good results might have been obtained in many of these joints destroyed by arthritis, but with some motion remaining, if no material had been placed between the articular surfaces. This has not been the experience of the authors, nor has it been the finding of those with wide experience in arthroplastic procedures. The only joints which have maintained good motion and have been free from pain after débridement or synovectomy have been knees with osteo-arthritis but with little incongruence or articular degeneration. In knee joints with widespread destruction of hyaline cartilage, fibrous adhesions or bony ankylosis invariably developed after operative procedures unless material had been placed between the raw articular surfaces.

SUMMARY

In chronic arthritis, arthroplasty of the knee involves a number of problems which do not occur in other diseases. Nylon membrane has been found to be non-irritating and durable and has proved to be a satisfactory material to place between the articular surfaces. The indications for arthroplasty are not exact but are dependent upon the degree of disability of the arthritic patient. The commonest postoperative complication is restriction of flexion. A satisfactorily functioning knee was obtained in fifty-eight of seventy arthritic knees subjected to the procedure described herein.

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DISCUSSION

Dr. Robert A. Knight, Memphis, Tennessee: To me, this is an important paper. For one thing, it marks the end of one era and the beginning of another.

It has been recognized for a long time that fascial arthroplasty of the knee is contra-indicated in chronic arthritis—Dr. Speed and Dr. Trout stressed that point in Quebec in 1948.

Suitable candidates for fascial arthroplasty of the knee, in the sense of the ideal case, with ankylosis resulting from an acute suppurative arthritis, are almost extinct, thanks largely to the chemotherapeutic and antibiotic agents.

Even though cortisone, ACTH, and compound F are of great value, the problem of atrophic arthritis is still with us. Also, there are many patients with degenerative arthritic knees whose problem is not entirely solved by compound F, patellectomy, and "surgical housecleaning"; it is hoped that nylon arthroplasty will open another avenue of approach in the orthopaedic treatment of these patients.

Dr. Kuhn's results, to date, are good. We found, in evaluating fascial arthroplasties, that at least five years must elapse before a so-called end result can be reached. Since it is quite probable that this will likewise prove to be true in this type of knee reconstruction, I hope that Dr. Kuhns and I will have the privilege of discussing this same subject five years hence. In the meantime, I shall certainly give the method a fair opportunity to prove its worth.

Dr. Carroll B. Larson, Iowa City, Iowa: Dr. Kuhns has given you the results of knee arthroplasty in which nylon has been the material of interposition. With the exception of the interposition material, the technique does not vary appreciably from that which has been used for many years. Nylon, presumably, has properties of pliability similar to fascia, with the addition of durability and inertness. The major question in my opinion, however, is whether more nearly congruous surfaces will result from nylon, since the functional

result will be dependent thereon. We need, therefore, to compare the known results of fascial arthroplasty with those where nylon has been used.

Speed and Smith, in a ten-year review of fascial arthroplasty, have stated that in well selected cases, rather exclusive of rheumatoid arthritis, 75 per cent. should succeed with an average range of motion of 50 to 60 degrees. The University of Iowa figures will match this very closely. We have based this on the last sixteen consecutive cases which have a four-and-a-half year follow-up or more. Stability and pain have been very similar in these results to the results that Dr. Kuhns has given you. On the basis of the above comparison, the functional result, however, of nylon arthroplasty is somewhat better, although not a dramatic improvement upon the fascial arthroplasties of the past.

Progress is in the proper direction, but we must seek further a method that will give better joint congruity if we are to have better results of arthroplasty of the knee in the future.

DR. KUHNS (closing): I want to thank the discussors for their comments, particularly Dr. Larson for his note of warning.

We do not get perfect knees. I do not know whether we will ever get perfect knees after arthroplasty in chronic arthritis. The tissues are all diseased, the bone is atrophic, the muscles are weak, and the supporting tissues are defective.

We believe, with Allison and Brooks, that the ideal substance for interposition in arthroplasty of the knee would be an absorbable material that would cause no irritation and that would persist until the active production of granulation tissue has ceased. A material of this type still awaits discovery, and until we do find something of that type we shall have to use nylon or some newer plastic, because fascia is too defective. These operations must be done with great care in the selection of patients because everything that is wrong can happen in patients with chronic arthritis.

DISCUSSION

OSTEOID OSTEOMA IN THE HAND

(*Continued from page 893*)

DR. LEO MAYER, NEW YORK, N. Y.: Just a few words to supplement what has been said so well by our speaker.

X-ray therapy has been mentioned as a possible means of treatment. We can assure you it is of no earthly value. Operation is the one way of curing the patients. In doing the operation, there are two precautions that we have found of considerable value. Our experience at the Hospital for Joint Diseases is based on more than a hundred cases. First, avoid block dissection. By this I mean do not cut out a large section of bone with a motor saw, thus impairing the strength of the bone. This may be of little significance in the case of a metacarpal, but it is extremely hazardous when one is dealing with the humerus or the tibia. A fracture may easily occur and in one case that I know of non-union ensued, so that five additional operations were required.

Second, be sure to remove the nidus. This usually is easily recognized by its characteristic appearance. In most of the cases, it is a bright cherry red. Sometimes, however, it is hard to find, and in these instances, x-ray control is of utmost importance. In one instance, failure to observe this precaution led to a most embarrassing situation: I thought I had removed an osteoid osteoma of the ilium, but x-ray films several days later showed that I had missed the nidus and, consequently, I had to repeat the operation. Had I taken an x-ray on the operating table, I should have found out my mistake sooner.

Finally, one word about the case described in 1932 by Dr. Jaffe and myself. Dr. Carroll is quite correct in not considering this an osteoid osteoma. It belongs rather in a group of very rare bone lesions, corresponding in some respects to sarcomata, but fortunately not malignant and not recurrent, if properly removed. I, myself, have never found a second like it. Similar cases have been described in the Swedish literature.

DR. CARROLL (closing): I want to thank Dr. Mason and Dr. Mayer for their kindness in discussing this paper.

It is certainly necessary to excise the nidus to obtain improvement in such a case of osteoid osteoma. It is not always necessary that the pathologist be able to demonstrate the nidus in the sections. Roentgenograms after operation will demonstrate the extent of the surgical procedure.

THE AGE INCIDENCE OF NEURAL-ARCH DEFECTS IN ALASKAN NATIVES, CONSIDERED FROM THE STANDPOINT OF ETIOLOGY

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INTRODUCTION

Each half of a neural arch, consisting of pedicle, transverse process, superior and inferior articular facets, and lamina, is formed normally from a single primary ossification center. The rarity of an extra center of ossification here is now well established on the basis of studies of late foetus and newborn infants[10]. It follows, therefore, that an interruption of continuity discovered in one or both hemi-arches later in life is unlikely to have persisted from a stage prior to ossification; in other words, the interruption represents a loss of bone continuity rather than a gap resulting from an anomalous and imperfect mode of ossification. In this sense the separate neural arch, involving as it usually does defects in the interarticular regions, is seldom congenital*. On the other hand, failure of the two halves of the arch to unite in the middle posteriorly obviously is much more likely to represent non-union of the respective ossification centers, and hence is usually (and perhaps always) congenital.

Acceptance of the fact that each half of the neural arch is usually intact at the outset of postnatal life, whereas it is often defective in adults (varying from about 5 to 50 per cent. according to racial group), raises the question whether the incidence of defects increases at a regular or irregular rate during life. This question, the answer to which should have a bearing on a theory of etiology, has not been satisfactorily answered so far, partly because few skeletons of subadults from present populations are available for study, and partly because no one has studied an adequate series of roentgenograms of subadults. Of course, since the incidence of the separate arch in adult whites and negroes is only around 5 per cent., it would take a fairly sizable series at each of the lower age levels in these groups to validate the age incidence statistically.

Knowledge of the pattern of occurrence of arch defects is needed in order to distinguish among such causative factors as (1) fractures at birth through hyperflexion of the spine[1]; (2) strain resulting from the assumption of upright posture in early childhood[13]; (3) direct injury[8]; (4) chronic trauma[6, 7]; and others. Roche and Rowe[9, 10] recognized the importance of this information, but unfortunately had available in their first study only fifty-one white and negro skeletons below the age of twenty, and in their second study only 140 roentgenograms of children between the ages of three and sixteen. Naturally with an adult incidence very little exceeding 5 per cent., their finding of only three children with separate arches could not lead to a statistically significant conclusion. At most, they believe, this finding is suggestive only of "an incidence of defects mid-way between the frequency in the adult and the total absence at birth".

In view of the limited information available at present on the age incidence of neural-arch defects, and because such information is now critical for the development of concepts of etiology, the writer feels justified in presenting some unique data from archaeological sources. The significance of these data from the standpoint of etiology will be discussed.

* The expression "separate neural arch" obviously describes defects which are bilateral, because otherwise the arch is not really separate. Yet it is certain that most authors have included unilateral defects thereunder. It seems simpler and more accurate to speak of a "defective neural arch" or in general "neural-arch defects".

TABLE I

INCIDENCE OF CASES WITH ARCH DEFECTS BY REGION AND AGE PERIOD

Region	Age Periods (*Years*)							
	Up to 6 years	7 to 12	13 to 18	19 to 24	25 to 30?	31? to 40?	41? and Over	Total
North of Yukon								
No. of skeletons	4	6	26	27	28	73	79	243
No. with arch defects		1	4	5	8	40	40	98
Per cent.		*15.9*			*28.6*	*54.8*	*50.6*	*40.3*
Between Yukon and Aleutians								
No. of skeletons	8	8	11	21	55	89	76	268
No. with arch defects		1	2	1	6	19	12	41
Per cent.		*8.3*			*10.9*	*21.3*	*15.8*	*15.3*
Aleutians and Kodiak Island								
No. of skeletons	11	12	32	29	39	65	87	275
No. with arch defects	1	1	4	7	7	18	30	68
Per cent.		*15.5*			*17.9*	*27.7*	*34.5*	*24.7*
Totals								
No. of skeletons	23	26	69	77	122	227	242	786
No. with arch defects	1	3	10	13	21	77	82	207
Per cent.	*4.3*	*11.5*	*14.5*	*16.9*	*17.2*	*33.9*	*33.9*	*26.3*

MATERIAL

The material from which these data were obtained, already in part described [12], consists of the skeletons of Alaskan Eskimos and Aleuts preserved in the United States National Museum. That the data are unique may be judged from the fact that almost literally every second adult skeleton from north of the Yukon River shows one or more defective arches (the percentages vary regionally). Because of this high adult incidence, relatively small numbers of subadults suffice to establish the incidence in the lower age periods. These subadults, incidentally, had not been included in the writer's earlier study.

It should be stated in addition that these skeletons were collected mainly by the late Dr. Aleš Hrdlička from about 1926 through 1938. He visited every identifiable and accessible native cemetery along the coasts of Alaska and along the lower reaches of the Yukon and Kuskokwim Rivers[2, 3, 4]. In most cases he took all the skeletal material he could transport. If selection was made at all, it was only on the basis of the state of preservation or gross abnormal variation. Such an inconspicuous thing as separate neural arch was never the basis of selection in the field. Evidence to this effect is afforded by the failure to collect the separated arches in some instances.

Some of the burials had been made long ago—as long as 1,000 years; others had occurred within the last fifty years. Thus the state of preservation varies somewhat with burial age, a fact which is reflected in the sample mainly in the subadult range, because children's bones do not last as long as those of adults. Moreover, it is the custom of the Eskimos to place personal belongings of the deceased on their graves, thus rendering the grave conspicuous according to the individual's wealth. Such factors probably account for the numerical inequalities of the sample at different age levels. Nevertheless, it should be apparent that in many respects this is an unusual and valuable collection which cannot be duplicated.

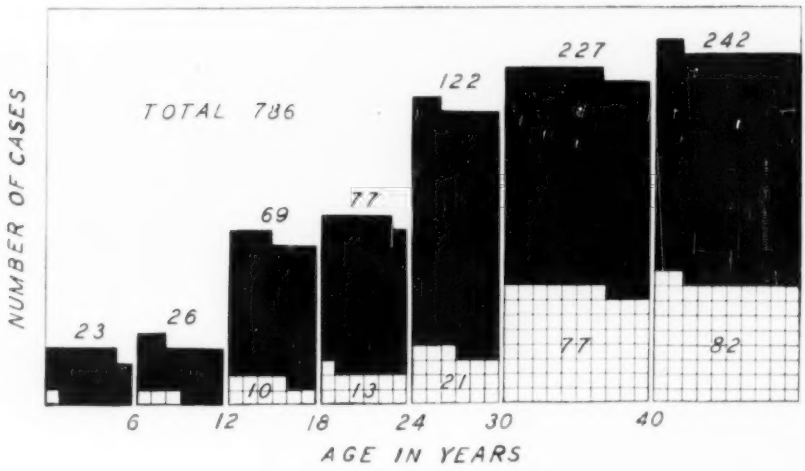

CHART I

Showing the total number of cases examined in each age group (figures at top of each column) and of these the numbers with one or more defective arches (figures within the white areas of the columns). The corresponding percentages are given in Table I.

RESULTS

A sorting of the whole sample of 786 specimens by age group and region is given in Table I. A somewhat unusual age grouping has been used, because exact age is unknown and the estimates thereof must be fitted to recognizable events in skeletal development. The age of six years is marked for all practical purposes by the eruption of the first permanent molar. Likewise, twelve years is marked approximately by the eruption of the second permanent molar. The distal epiphyses of the ulna and radius begin to unite at about eighteen or nineteen years; the medial epiphysis of the clavicle at about twenty-five years. With the union of this last major epiphysis, it is necessary to turn to a differe... type of age change. Here convenience has dictated the use of progressive stages of hypertrophic arthritis in the spine. This type of bone change, admittedly, is only roughly correlated with age, and indeed may at times reflect the presence of arch defects, yet it seems to yield a chronological division which is adequate for the purpose. There is no doubt that persons who show no lipping of the vertebral bodies in general are younger than those with slight lipping, and that in turn the latter are younger than those with moderate or pronounced lipping, but it is not known to what age ranges in the Eskimos and Aleuts these classes of arthritic involvement correspond. The onset of arthritis has therefore been estimated to be at thirty years and the moderate stage of arthritis at forty years.

The regional subdivision also requires explanation. At the time of the author's first publication on this subject [12], the progress of collection had just moved from northern Alaska to include the Yukon and parts immediately to the south. The writer detected a lesser frequency of arch defects in the latter area and hence compared the two groups. After that time material was collected in the area just above the Aleutians, and subsequently collections were made in the Aleutians and on Kodiak Island. Since the Aleuts and Koniags show some cultural and physical differences from their relatives to the north, they have been placed in a third group.

The observations made in the earlier publication are repeated in Table I; namely, that separate neural arch is most common north of the Yukon River and less common from the Yukon south to the Aleutians. Moreover, it now appears that in the Aleutian Islands and on Kodiak Island the incidence again increases. If only the adults with

TABLE II

INCIDENCE OF CASES WITH ARCH DEFECTS BY REGION, STATE OF MATURITY, AND SEX

Region	Subadults* (13 to 24 years) Male	Subadults* (13 to 24 years) Female	Adults** (25 years and over) Male	Adults** (25 years and over) Female
North of Yukon				
No. of skeletons	24	22	90	86
No. with arch defects	3	4	44	40
Per cent.	*12.5*	*18.2*	*48.9*	*46.5*
Between Yukon and Aleutians				
No. of skeletons	13	14	105	115
No. with arch defects	2	1	22	15
Per cent.	*15.4*	*7.1*	*21.0*	*13.0*
Aleutians and Kodiak Island				
No. of skeletons	29	23	107	82
No. with arch defects	8	3	41	13
Per cent.	*27.6*	*13.0*	*38.3*	*15.8*
Totals				
No. of skeletons	66	59	302	283
No. with arch defects	13	8	107	68
Per cent.	*19.4*	*13.6*	*35.4*	*24.0*

* This includes all those in Table I from thirteen to twenty-four years, except for twenty-one cases in which the sex is unknown.

** This includes all those in Table I of twenty-five years and over, except for six cases in which the sex is unknown.

arthritis or those over thirty years of age are considered, the regional differences vary as follows: north of the Yukon, 52.6 per cent.; south of the Yukon, 18.8 per cent.; Aleutians and Kodiak Island, 31.6 per cent. All of these differences are statistically significant. However, the term "regional" as applied here to differences in the incidence of separate neural arch does not indicate the real causative factors. We shall return to this matter later, to see whether environmental or cultural differences are masked by this designation.

As regards progression with age, the chief point of interest here, Table I shows a rapid rise in frequency of defects to the age of puberty and then a more gradual increase until the estimated age of thirty, following which, as arthritis makes its appearance, the incidence doubles. From about forty years of age onward, such defects do not seem to become more common. This is shown graphically and on a numerical basis in Chart I.

TABLE III

INCIDENCE OF CASES WITH ARCH DEFECTS BY SEX AND AGE PERIODS

Sex*	Age Periods (*Years*) 13 to 18	19 to 24	25 to 30?	31? to 40?	41? and Over	Totals
Male						
No. of skeletons	35	31	62	109	131	368
No. with arch defects	6	7 (2)**	11 (2)	41 (7)	55 (12)	120 (23)
Per cent.	*17.1*	*22.6*	*17.7*	*37.6*	*42.0*	*32.6*
Female						
No. of skeletons	15	14	59	115	109	342
No. with arch defects	2	6 (1)	9 (3)	34 (7)	25 (9)	76 (20)
Per cent.	*13.3*	*15.6*	*15.2*	*29.6*	*22.9*	*22.2*

* The sex of many of the younger and a few of the older specimens could not be determined.

** Cases of multiple segmental involvement are shown in parentheses.

TABLE IV

DISTRIBUTION OF SIX TYPES OF DEFECTIVE ARCH BY SEGMENT AND AGE PERIOD

Type and Segment	Age Periods (Years) Up to 6 (No. of Defects)	7 to 12 (No. of Defects)	13 to 18 (No. of Defects)	19 to 24 (No. of Defects)	25 to 30? (No. of Defects)	31? to 40? (No. of Defects)	41? and Over (No. of Defects)	Total
Type A								
Lumbar 5*		2	7	7	11	48	53	128
Lumbar 4				4	10	26	29	69
Lumbar 3				1	1	4	9	15
Lumbar 2						1		1
Total		2	7	12	22	79	91	213
Type B								
Lumbar 5		1	1	1		4	5	12
Lumbar 4						1	2	3
Lumbar 2						1		1
Total		1	1	1		6	7	16
Type C								
Lumbar 5			1		1	2	3	7
Lumbar 4					1		1	2
Lumbar 3						1		1
Lumbar 2							1	1
Lumbar 1						2	2	4
Total			1		2	5	7	15
Type A_1								
Lumbar 5	1		1	2			1	5
Type B_1								
Lumbar 5				2	2	2	3	9
Type C_1								
Lumbar 5						1		1
Total	1	3	10	17	26	93	109	259

* It is not always possible to say whether the last free vertebra is the fifth or the sixth lumbar. Partial connection of a vertebra with the sacrum (sacralization or lumbarization) also complicates the picture. To simplify tabulation, therefore, all such doubtful cases have been listed here and elsewhere under "Lumbar 5".

Any doubt regarding the statistical significance of this age progression, especially because of the small numbers in the lowest age groups, is dispelled by the χ^2 test. There is only a small possibility that such an arrangement would be produced by chance. And, of course, the possibility of repetition of this arrangement by chance in all three regional groups is very much smaller.

Consideration of age progression would be incomplete without some reference to the sex ratio, another factor affecting the sample. Since we are dealing with the skeleton and not just the skull, the estimation of sex can be considered correct in 95 per cent. or more of the adults. In only the oldest subadults, however, is it possible to approach this degree of reliability.

It will be seen from Table II that the representation of the two sexes among the adults is variable in the three areas. If the observed male skeletons in an area are taken to be 100, then the female skeletons compare as follows: north of the Yukon, ninety-six; south of the Yukon, 110; Aleutians and Kodiak Island, seventy-seven. Or, if we combine all the adults, we find that there are ninety-four females to 100 males. Thus, the most marked disproportion in the representation of the two sexes among the adults is in the Aleutians and on Kodiak Island.

So far as the evidence goes, much the same ratio of representation is found in those subadults which the writer attempted to sex. They number 125; of these sixty-six are

TABLE V

INCIDENCE OF CASES OF SINGLE DEFECTIVE ARCH BY SEGMENT AND AGE PERIOD

Segment	Age Period (*Years*) Up to 6 years (*No. of Defects*)	7 to 12 (*No. of Defects*)	13 to 18 (*No. of Defects*)	19 to 24 (*No. of Defects*)	25 to 30? (*No. of Defects*)	31? to 40? (*No. of Defects*)	41? and Over (*No. of Defects*)	Total
Lumbar 5	1	3	10	9	10	45	45	123
Lumbar 4				1	5	15	14	35
Lumbar 3					1	1	1	3
Lumbar 2						1		1
Lumbar 1						1		1
Total no. of cases and segments	1	3	10	10	16	63	60	163
No. of skeletons examined	23	26	69	77	122	227	242	786
Per cent.	*4.3*	*11.5*	*14.5*	*12.9*	*13.1*	*27.7*	*24.8*	*20.7*

regarded as males, fifty-nine as females. Using again 100 males as a standard of comparison, we get a figure of eighty-nine for females. These figures show closer equality of representation than do those for the adults of the Aleutians and Kodiak Island.

Regardless of the sex disproportion in the sampling, the difference in incidence of neural-arch defects between the two sexes seems actually to vary regionally. The greatest adult sex difference, 22.5 per cent., is in the series from the Aleutians and Kodiak Island; the least, 2.4 per cent., is in the series from north of the Yukon. Between these extremes comes the intervening series (south of the Yukon) with a difference of 8 per cent. When the regional samples are combined, the adult sex difference amounts to 11.4 per cent. If a statistical test of significance (χ^2) is applied, the sex difference for north of the Yukon

TABLE VI

INCIDENCE OF CASES OF MULTIPLE DEFECTIVE ARCHES BY SEGMENT AND AGE PERIOD

Combinations of Involved Segments	Age Period (*Years*) Up to 6 Years (*No. of Defects*)	7 to 12 (*No. of Defects*)	13 to 18 (*No. of Defects*)	19 to 24 (*No. of Defects*)	25 to 30? (*No. of Defects*)	31? to 40? (*No. of Defects*)	41? and Over (*No. of Defects*)	Total
Lumbar 5 and 4				2	5	9	11	27
Lumbar 5, 4, and 3				1		2	4	7
Lumbar 5 and 3						1	2	3
Lumbar 4 and 3						1	2	3
Lumbar 5 and 1							2	2
Lumbar 5, 4, and 2							1	1
Lumbar 2 and 1						1		1
Total no. of cases*				3 (7)	5 (10)	14 (30)	22 (49)	44 (96)
No. of skeletons examined	23	26	69	77	122	227	242	786
Per cent.				*3.9*	*4.1*	*6.2*	*9.1*	*5.6*

* Segments shown in parentheses.

FIG. 1

FIG. 2

Fig. 1: A fifth lumbar vertebra with Type A defect—bilaterally through the pars interarticularis—in a female, near twenty years, from Point Hope, Alaska (United States National Museum No. 346,197).

Fig. 2: A fourth lumbar vertebra with Type B defect—unilaterally through the pars interarticularis—in a male over twenty-five years (but with very slight vertebral lipping) from the Kuskokwim River, Alaska (United States National Museum No. 351,224).

Fig. 3: A fifth lumbar vertebra with Type C defects—through the pedicle on one side (on the left in this specimen) and through the pars interarticularis on the other—in a male (?) between twelve and fifteen years from Amchitka Island (Aleutian Islands), Alaska (United States National Museum No. 378,696).

Fig. 4: A fifth lumbar vertebra with Type A_1 defects—bilaterally through the pars interarticularis and in the midline posteriorly—in a child near six years from Kodiak Island, Alaska (United States National Museum No. 374,690).

FIG. 3

FIG. 4

could be due to chance. Elsewhere, and all taken together, the sex difference is statistically significant. Also, it is apparent that the sex difference always favors the male.

When we compare these findings for the adults with those for the subadults, the sex difference is small in the latter (5.8 per cent.) and could be due to chance. However, the direction is again in favor of the male. From this it might be concluded that sex is a definite factor in the incidence of neural-arch defects in Alaska. Yet nowhere, except in the Aleutians and Kodiak Island, does it reach the male-female ratio of two to one which is characteristic of whites.[9] It is possible that the unequal sex distribution in the Aleutians and Kodiak Island mentioned above has something to do with this exception.

According to Table III, in which the data from the three regions are pooled, the sex difference is rather constant from thirteen to eighteen years upwards. Before puberty, of course, it is practically impossible to sex the skeleton.

Next the location and types of the arch defects at each age period will be considered. For this purpose three principal types and three subtypes of defects have been distin-

FIG. 5

FIG. 6

FIG. 7

Fig. 5: A fifth lumbar vertebra with Type B_1 defects—through the pars interarticularis on one side (on the right in this specimen) and in the mid-line posteriorly—in a male over twenty-five years (but with slight vertebral lipping) from St. Lawrence Island, Alaska (United States National Museum No. 368,286).

Fig. 6: Fifth lumbar vertebra with Type C_1 defects—through the pedicle on both sides (in this specimen behind the transverse process and not in front of it as in Fig. 3). In addition there is a defect through the pars interarticularis on the left, so that the superior articular process on this side is a separate piece of bone (not shown). The specimen is from a female over twenty-five years (but with slight vertebral lipping) from St. Lawrence Island, Alaska (United States National Museum No. 346,069).

Fig. 7: Roentgenogram of a third lumbar vertebra with Type C defects (see also Fig. 3). The defect through the right pedicle is partly united. Note the marked repair reaction here in contrast to the lack of such reaction about the defect through the left pars interarticularis. The specimen is from a male over twenty-five years (but with slight vertebral lipping) from Seward Peninsula, Alaska (United States National Museum No. 352,373). (Roentgenogram by courtesy of Georgetown University Hospital, Washington, D. C.)

guished. The principal types are as follows: Type A, those occurring bilaterally through the interarticular portion of the arch (Fig. 1); Type B, those occurring in the same place, but on one side only (Fig. 2); and Type C, those which combine a unilateral interarticular defect with a defect through the pedicle, either anterior or posterior to the transverse process (Fig. 3). Of the subtypes, two, Types A_1 and B_1 (Figs. 4 and 5) are simply Types A and B with the addition of a posterior median defect (spina bifida). The third subtype, Type C_1 (Fig. 6) designates a single, and hence obviously rare, case in which the defect was bilateral and through the pedicles*. Defects in the posterior mid-line unaccompanied by other defects have not been considered.

Table IV shows the progressive involvement of the lumbar segments with advancing age, together with a parallel increase in the more unusual types of defects. At the outset only the fifth lumbar vertebra is involved and the defect is one of the predominant types (Type A or B); that is, it is located in the interarticular region and involves one or both sides. Apparently the fifth lumbar also shares with the sacrum a delay in the fusion of the

* From the standpoint of classification, the fact that the specimen illustrated in Figure 6 had an additional defect through the isthmus on the left side will be ignored.

arch in the mid-line posteriorly. This hiatus, unlike the other defects, decreases rather than increases in frequency with age. Type C, involving one of the pedicles, makes its appearance in the age period thirteen to eighteen. Multiple segmental involvement enters in the following age period, nineteen to twenty-four. Finally, it is noteworthy that a considerable increase in most categories marks the period from thirty-one(?) to forty(?) years.

Tables V and VI supplement Table IV by showing the segmental involvement by age period in cases of single and multiple defects. In general they tell the same story of an increasing incidence with age, together with an upsurge in frequency during the age period thirty-one (?) to forty (?).

In view of the fact that increasing numbers and kinds of arch defects appear with age, the question arises whether the sex difference in frequency shown earlier carries with it a sex susceptibility to type of defect. This is not easy to determine without a larger sample, since all the types, except Type A, are of infrequent occurrence. There is a strong indication, however, that, so far as these Eskimos are concerned, Types C and C_1 with one or both pedicles defective, are more apt to occur in females than in males. Of twelve examples in this series nine are females. The left pedicle is defective in eight cases, the right in three; both pedicles are involved in one case.

The writer is inclined to suspect direct injury as the cause of pedicle defects. As the x-ray of one such case shows (Fig. 7), there is callus formation at the site of the defect in the pedicle. However, in this small series of pedicle defects union was in progress in only two cases. The tendency for pedicle defects to occur mostly on the left side may be related to handedness and may reflect an effort to prevent the injury.

DISCUSSION

The data presented herewith provide the rates of accumulation of the various patterns of neural-arch defects through the periods of growth and adult life in Alaskan natives. Although there are marked regional differences, the general rate of increase is fairly regular up to early adult life, progressing from around 5 per cent. at six years of age to 17 per cent. at approximately thirty years of age. Coincident with the appearance of hypertrophic arthritis of the spine, judged to take place between the ages of thirty and forty, the incidence of arch defects rises rapidly to about 34 per cent. and probably does not increase thereafter. No other racial group is known to approach this high frequency. Progression with age is further evidence that lateral arch defects are not congenital.

Except perhaps for the peoples north of the Yukon, males have a higher incidence of the defects than do females. This sex difference seems to hold at all age periods. However, the sex difference rarely reaches the ratio of two to one reported for whites.

The increasing incidence of the defects with advancing age includes a spreading segmental involvement together with added defects at unusual sites. From the beginning and throughout life, the most common defect is located in the interarticular region of the fifth lumbar vertebra. The other vertebrae, usually with the same type of defects, follow in ascending order of frequency, either singly or in combinations. Thus, although multiple defects were not found below the age period nineteen to twenty-four, they reached a frequency of 9 per cent. in old adults.

The types of defect which involve one or both pedicles and have the characteristics of fractures were not found in subadults. In twelve specimens with pedicle defects, the majority were in females and were on the left side of the arch. Otherwise there does not seem to be a sex predisposition to a particular type of defect.

It is evident from this summary that there is something peculiar to the Alaskan natives which causes them to acquire neural-arch defects in the lumbar vertebrae much more frequently than other people. The factors favoring such a high incidence are most effective north of the Yukon River—so effective indeed that the usual sex difference is here nearly obliterated. What are these causative factors?

FIG. 8

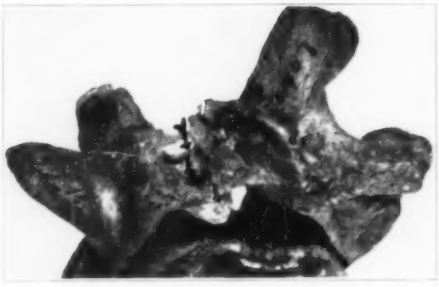

FIG. 9

Fig. 8: View of the left pars interarticularis in a fifth lumbar vertebra from below and slightly to the left. The arrow points to a crack which may be the beginning of a fatigue fracture or pseudofracture. The specimen is from a female, between twenty and twenty-five years old, from Amaknak Island (Aleutian Islands), Alaska (United States National Museum No. 377,752).

Fig. 9: Another specimen of a fifth lumbar vertebra viewed from the same angle. The arrow indicates a much more extensive crack, but still one which is incomplete inferiorly. Compare this with the specimen shown in Fig. 2. The specimen is from a male over twenty-five (there is moderate arthritis) from Kagamil Island (Aleutian Islands) Alaska (United States National Museum No. 377,907).

In his earlier publication on this subject [12] the writer assumed, in accordance with prevailing opinion, that these defects were hereditary. Accordingly, he was led to conclude that there was something in the racial composition of the Alaskan populations which, combined with inbreeding, explained the regional variations in incidence. The new evidence of progression in incidence with age from about zero at birth makes this explanation untenable. In view of this evidence it must be admitted that the Eskimo physical type or body build is not far different in any part of Alaska as compared with any other part, and certainly not very different from that of other Mongoloid peoples who are not so subject to arch defects; nor is inbreeding so much more intense in some parts of Alaska than in others. Even the sex difference, which at one time seemed compatible with the genetic theory, must have a different explanation in view of its absence north of the Yukon.

To abandon heredity as an explanation is to subscribe to an explanation based on mechanics. All the new evidence, and especially the age incidence, urges the acceptance of this view. However, a mechanical explanation involves factors which can no longer be connected directly with the skeletons. Thus, although something can be said about the skeletons themselves—facts of heredity, such as race, sex, age, and body build—almost nothing can be determined about the experiences of these individuals in life, such as their postural habits, occupational proclivities, accident proneness, or other factors. We can be sure, however, that injuries to the back were very inadequately treated from the standpoint of modern medicine. At this point, therefore, discussion enters the realm of speculation.

Before speculating on the elements in Eskimo life which have a bearing on the high incidence of arch defects, it is necessary to characterize the defects themselves more accurately. The opinion was expressed above that defects through the pedicles (Types C and C_1) are fractures. This supposition is based mainly on the callus formation present, for there is no evidence of associated fractures in other bones. In all such cases which have come to the author's attention, however, there is a co-existing interarticular defect on the opposite side. It may be assumed, therefore, either that the interarticular defect was caused at the same time as the pedicle fracture or that it preceded and predisposed to this fracture. The pedicle being stout bone, it is difficult to account for its fracture except through a direct blow, perhaps with previous weakening of the arch at another point. If this is so, then fractures of both interarticular isthmi (or of one isthmus where there is an associated congenital defect on the posterior mid-line) due to injuries should be even more common than pedicle fractures.

FIG. 10

Unusual posture assumed by Eskimo women while they are engaged in cleaning sealskin. Photograph taken at Wales, Alaska, in 1936 by Henry B. Collins, Jr. (Courtesy of the National Geographic Society, Washington, D. C.).

Unlike the pedicle defects, the interarticular defects do not show evidence of repair in the form of callus. Has this distinction any significance in connection with the etiology of interarticular defects? Thieme discusses this point after describing Hitchcock's production of fractures by hyperflexing the bodies of stillborn children (which, incidentally, Rowe and Roche[10] could not reproduce):

". . . This demonstrates that the arch is easily broken at this time without exaggerated forces or trauma necessary to accomplish it, and also that the mechanical stresses of the area, and not necessarily localized trauma, can cause the breaks. It leaves open, however, the question of lack of repair. Possibly these breaks are quite frequent and more often healed than is known with only the non-healing cases remaining as spondylolysis; or, possibly, blood supply or osteogenesis are interrupted because of the hourglass-shaped center where the break occurs. The pattern for this anomaly is not typical and the explanation of why osteogenesis ceases at the lesion and repair does not take place must await detailed work on this particular area in the vertebrae."

After pointing out that most of the experimental work on bone repair has been done on long bones, he goes on to say:

"If the injury causes cartilage or dense connective tissue to form in the manner suggested . . . by Weinmann and Sicher, and this is implemented by shearing forces, which are the primary mechanical variant introduced by lumbar curvature, then the lack of callus formation is explained."

Another explanation, which may account for the lack of repair and which eliminates the possibility of direct injury, has been advanced by Roberts. He pointed out that

"Wendell G. Scott has described [the pars interarticularis] as 'a strategic connecting point in the neural arch and for that reason subjected to great stresses and strains.' It is more than this however for (a) in the anteroposterior plane, it is the pivotal centre between the pedicle (and body) and the lamina (and spinous process), (b) in the vertical plane, it is between the superior and inferior articular processes, which are most concerned with guiding the vertebral movements, and (c) in the lateral horizontal plane, it is at the base of the transverse process."

"From the structural point of view, the pars interarticularis is preeminently a site at which one should look for the effects of overstrain of the bony tissue, being a delicate structure and a pivotal centre for powerful stresses and strains. It is submitted that these defects under discussion are primarily the result of overstrain deossification."

Roberts likens this process of de-ossification in the neural arch to the so-called "march fracture" in the metatarsals, which is a fatigue or pseudofracture.

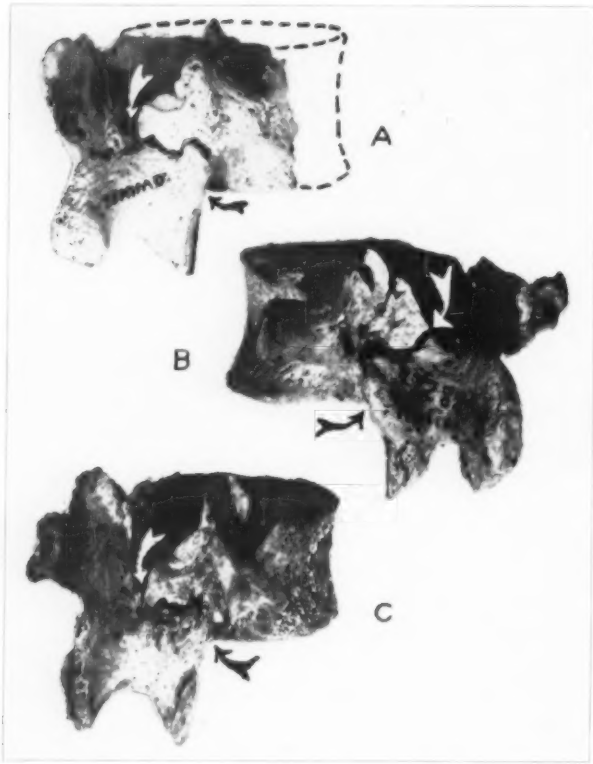

FIG. 11

Three upper lumbar vertebrae viewed posterolaterally. Note the uniform pattern of the defects indicated by the arrows. In each case the inferior portion of the defect has the character of a true joint.

A: A first lumbar vertebra from a specimen of unknown sex, showing considerable arthritis, from St. Lawrence Island, Alaska (United States National Museum No. 279,636).

B: A second lumbar vertebra from a female (?) showing slight arthritis, from Kodiak Island, Alaska (United States National Museum No. 372,887).

C: A first lumbar vertebra in a female with slight arthritis from Golofnin Bay, Alaska (United States National Museum No. 346,022).

Little consideration has been given to the extra stresses within the lower back, which, in contrast to injuries and beyond the fundamental adaptations to upright posture, are of a chronic nature and perhaps lead to de-ossification and interarticular pseudofracture. It seems likely that strange body positions required by special occupations and endured for long periods of time might supply some of these extra stresses. Conceivably, also, ruptured disc, in itself possibly a sign of strain, would throw extra stress on the arches of the involved segments. Lindblom[5] has suggested that the site of disc rupture in modern man is explained by the fact that his spine "is to some degree fixed and posteriorly compressed by his unnatural habit of wearing shoes with heels".

Whatever the nature of the extra stresses, the resulting pseudofracture presumably would manifest itself grossly as a crack leading eventually to complete separation. Presumably also, it would be rare for death to coincide with the early stages of de-ossification, which would be the main reason that no one has observed them in skeletons. On the other hand, these beginning signs would not be seen unless especially looked for.

In the Alaskan skeletal collection there are two cases which show interarticular defects that may represent early stages of pseudofracture. In one (Fig. 8) there are small transverse cracks in both interarticular isthmi (especially on the left) which would be overlooked in a cursory examination, or perhaps attributed to postmortem changes; in the other (Fig. 9) there is nearly complete cleavage through the interarticular region on the left side. There may be other cases in the collection, but these are the only ones which caught the author's attention.

With these mechanical considerations in mind, we will examine the environmental settings and cultural patterns of the three groups of Alaskan natives under discussion. Perhaps some environmentally determined cultural procedures subject the low backs of these northern peoples to unusual strains and accidents.

It is well known that the Eskimos of Alaska and especially those of the northern part are subject for a large part of the year to limited sunlight, extreme cold, and attendant

ice and snow. To this radical environment they have adapted their mode of life in an ingenious and effective manner. An important item in this adaptation is the seal. This animal, hunted at every opportunity, provides such essentials as food, oil for heat and light, skin for making boots and covering boats, and rawhide rope for binding objects and making fishing lines. It is not surprising, therefore, that most Eskimos are coastal inhabitants. This is true of the peoples represented in the skeletal sample collected north of the Yukon; it is not entirely true of the peoples represented in the sample collected along the lower Yukon and southward to Bristol Bay. The coastal waters of the Bering Sea south of the mouth of the Yukon River are shallow and partly for this reason not very popular, so that with some exceptions (Hooper Bay, Nunivak Island. Nelson Island), most of the inhabitants live inland (especially along the Yukon and Kuskokwim Rivers). The third area under consideration, the Aleutians and Kodiak Island, being largely made up of islands, again forces its inhabitants into what might be called a maritime existence. Here, although the cold is not as intense as farther north, there is in addition a treacherous terrain and the constant hazard of dense fogs.

The modes of life which the Eskimos have developed to meet the needs of these different but extreme kinds of environment may be reflected in the correspondingly different frequencies of neural-arch defect. Certainly Eskimo existence is most rugged in the far North and here we encounter the highest frequency of arch defects. Next in severity probably comes the area which includes the Aleutians and Kodiak Island, which also yields the next highest frequency of defects. The intermediate, largely inland area comes third both in severity of living conditions and in the incidence of arch defects.

This parallel between environmental severity and the incidence of arch defects suggests injuries, especially from falls on ice. There can be little doubt that the Alaskan natives who are the subject of this study did travel often over ice and over rocky coastal terrains made slippery by ice and snow. Because of this circumstance, their rate of falls is probably much higher than that of other populations. However, simple falls are not known to cause breaks in the neural arches. If falls did cause many of the arch breaks discovered in these Alaskan natives, it would seem logical to conclude that there must have been predisposing weakness where the bone parted.

At this point it seems necessary to consider the idea of chronic strain leading to de-ossification discussed above. The Eskimos of Alaska, for their occupational activities, use a posture which to our way of thinking is impossible of long endurance. In a typical example shown in Figure 10, women are seen standing straight-legged and bent over in order to engage in hand operations at ground level. In this position the back and hip joints are hyperflexed while the lower extremities are nearly or fully extended. Most other people find the resultant extension of the hamstring muscles painful and hence kneel or sit down to such work. Eskimos do sit down to work, of course, but when they do so they often assume a similar position with the lower extremities fully extended in front of them. The men also sit in this fashion and are compelled to do so when they are in their slender, skin-covered boats (kayaks). Although the women may not stay in this strange position very long at a time, the men at least cannot change position as long as they are in the kayak, and that can be for more than an hour.

The effect of such a posture on the low back is to reduce the normal lumbar lordosis; it is the very opposite, therefore, of the effect produced in modern peoples by the wearing of heels. Whether the resulting extra stress is greatest at the level of the fifth lumbar vertebra and decreases with each succeeding upper segment can be judged only from the distribution of defects. The fact that in the Eskimos this extra stress is allowed to persist for long periods of time may be the distinctive feature in their way of life which leads to their very frequent acquisition of arch defects.

Is the explanation as simple as this? Cases of unilateral defect (Type B) do not fit into this scheme. As there is no motion in a sound arch, why should a complete cleavage develop

on one side alone, since the stress brought to bear on the other side would be increased? In one such case in a fifth lumbar vertebra where the defect is a thin line of cleavage, the pars interarticularis is stoutly constructed measuring thirteen millimeters transversely and nine millimeters anteroposteriorly (unaffected side: sixteen and nine millimeters respectively). Here, too, the distance between the tips of the superior and inferior articular facets is four millimeters greater on the affected than on the unaffected side.

Attention is called also to the fact that in the few unilateral cases involving the first and second lumbar vertebrae the details of the defects are quite uniform. Figure 11 shows the uniform pattern of these defects as well as the associated asymmetry. (In four cases the maximum distance between the tips of the superior and inferior articular facets on the affected side averages 49.8 millimeters as compared to 45.5 millimeters on the normal side.) If, as this suggests, anomalous ossification accounts for some of the defects in Eskimos—more perhaps than in whites and negroes—it can hardly be a major factor in the incidence.

These considerations lead the writer to believe that the unusual incidence of arch defects in Eskimos is due to the combination of unusual postural stresses, a high accident rate, and perhaps a somewhat more frequent occurrence of anomalous ossification. Only case histories of living subjects can give a better explanation.

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THE USE OF STAPLES AND BONE-CHIP GRAFTS FOR INTERNAL FIXATION IN FOOT-STABILIZATION OPERATIONS *

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Surgical stabilization of the paralytic or deformed foot is one of the most common operations performed by orthopaedic surgeons today. The various stabilizing procedures and techniques used for different deformities and disabilities of the foot have been amply described and profusely illustrated in the literature for many years. The deformities resulting from various diseases and injuries are well known and the indications for the employment of the different types of foot-stabilizing procedures to meet the requirements of the individual cases are fairly well standardized. There is no doubt that there has been a high percentage of good results from these procedures generally, but too few critical end-result studies have been published. The report by Patterson and his associates [1] is probably the best and most recent study and should be familiar to all. This study showed clearly for the first time that the end results of surgical foot stabilization are not as uniformly good as they might be. It also showed the causes for failure of different types of operative procedures in the various conditions for which they were used.

It is not our purpose in this paper to review all of the different types of foot-stabilization procedures and the indications for them. We intend to describe a method of internal fixation supplemented by bone-chip grafts which we believe has certain distinct advantages and gives better results than we had previously had when these supplementary measures were not used.

Surgical stabilization of the foot, although not usually difficult for an experienced surgeon, is nevertheless a tedious and sometimes extremely strenuous procedure in cases of marked deformity and severe injury.

The best results from foot stabilization may be expected only when there has been a careful preoperative evaluation of the patient as a whole, the deformity or disability of the foot itself, and the individual requirements of each case. In cases of marked deformity, if not enough bone is removed to correct the deformity at the time of operation, good results cannot be obtained even if all the joints fuse which should be fused. If overcorrection of the deformity is brought about by too much removal of bone, the result may be equally undesirable. Even if the proper procedure is selected for the individual case and exactly the proper amount of bone is removed to give the desired correction of the deformity and stabilization of the foot in proper position and alignment, loss of position and failure of fusion with pseudarthrosis in one or more joints may result in failure, due to pain or recurrence of deformity or both. This is the chief difficulty we have had in the past and is the main reason for the use of the supplementary measures in foot-stabilization procedures described here.

In most foot-stabilization procedures, when the operation has been completed, the foot consists of three separate parts and frequently these are very unstable. While it is sometimes possible to realign the different components of the foot and maintain them in the desired position without internal fixation, this is impossible to achieve in some cases and unreliable in others. Even when the desired position can be obtained, displacement of the apposing bone surfaces may occur while the cast is being applied or subsequently before fusion occurs. Such displacement may be the only cause of failure in the result and may necessitate re-operation to relieve pain or correct recurrent deformity.

To overcome the difficulty of accurately maintaining apposition of the resected joint surfaces, one of us (R.H.A.) adopted the use of internal fixation of the resected

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1953.

FIG. 1-A

FIG. 1-B

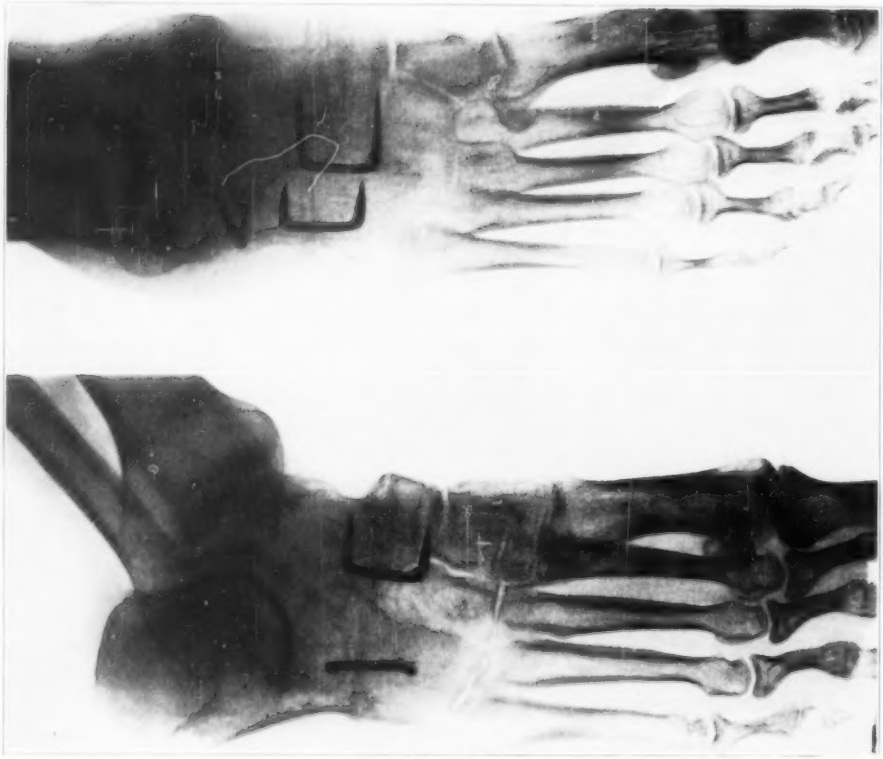

FIG. 1-C

Fig. 1-A: Roentgenogram made before operation, showing an old fracture of the calcaneus in a man forty-one years old.

Fig. 1-B: Roentgenogram made November 28, 1949, five months after triple arthrodesis, with three staples and bone chips, had been performed for painful foot. The cast, which consisted only of a below-the-knee plaster boot, had been removed seven weeks after operation.

Fig. 1-C: Anteroposterior and oblique roentgenograms made on the same day.

joints with the use of staples in June 1949. The use of bone chips, taken from bone removed from the site of resection at the time of operation, was also instituted in the hope of shortening the time of bone healing. The use of staples for internal fixation together with the implantation of bone-chip grafts has proved to have advantages other than those for which the procedure was originally chosen and will be referred to later.

Since June 1949 we and our colleagues have performed stabilization procedures of various types on sixty-three feet in fifty-five patients for most of the deformities and conditions for which stabilizing procedures are generally used. Metal staples have been used for internal fixation in all of these cases and bone chips taken from the bone removed at the operation have been used in the majority of them.

TECHNIQUE OF SURGERY

A thorough exposure of the region to be operated upon is essential here as elsewhere in surgery. Accurate removal with a sharp osteotome of all the joint cartilage from the joint surfaces to be fused is essential. After removal of the desired amount of bone for correction of deformity, the remaining bone surfaces are trimmed so that they are square and flat and the opposing surfaces fit each other accurately. It is important for all three components of the foot to be accurately fitted together before the first staple is introduced. If the resected bone surfaces do not fit in proper position and alignment, they should be made to do so. A staple of the proper size is selected for each joint in each foot. Usually, one staple is driven across the talocalcaneal joint while the joint is firmly compressed; the

FIG. 2-A

Fig. 2-A: Roentgenogram made July 14, 1950. The patient was a fourteen-year-old boy who had had poliomyelitis. A triple arthrodesis with three staples and bone chips was performed on February 15, 1951.

Figs. 2-B and 2-C: Anteroposterior and lateral roentgenograms made August 10, 1951, six months after operation, showed maintenance of position and solid fusion.

FIG. 2-B

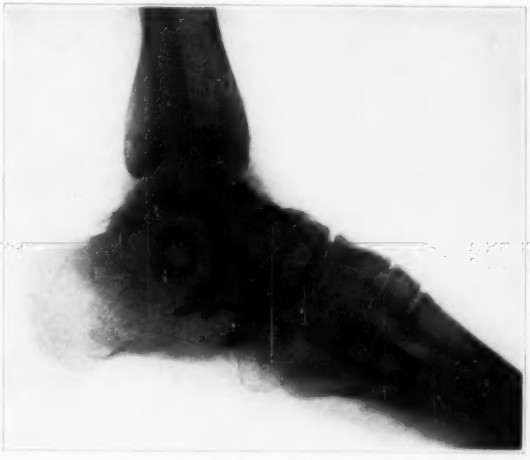

FIG. 2-C

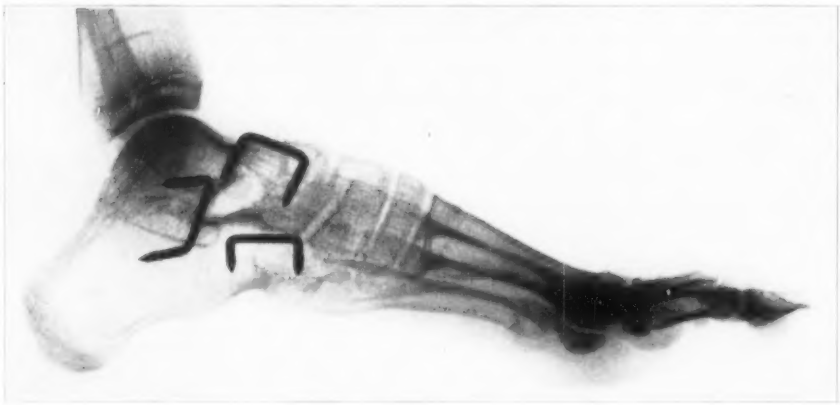

FIG. 3

Roentgenogram made October 25, 1951. The patient was a boy, eleven years old, who had a calcaneonavicular bar. A triple arthrodesis with three staples and bone chips had been done on February 24, 1950; immobilization in a plaster boot had been discontinued ten weeks after operation. This roentgenogram showed a satisfactory result.

staple should be driven in with as few strokes of the mallet as possible. The resected calcaneocuboid joint surfaces are then firmly held together while one or two staples are driven across the joint; one is usually adequate. Usually, the foot is well held together after these first two joints have been stapled so that the talonavicular surfaces are easily transfixed with one staple. In some types of foot stabilization, such as the Lambrinudi, only one or two staples are used, and in some cases no more than one is necessary. This one is placed across the calcaneocuboid joint in the Lambrinudi procedure. Whenever possible, however, each resected joint should be fixed with a staple.

It is essential that the opposing bone surfaces should not be distracted when fixed with staples. The position of the various components of the foot should be checked before each staple is applied. After fixation of the separate parts by staples, multiple cancellous bone chips taken from the portions of bone removed at operation are packed about the lines of resection and all defects are filled with the chips. The wound is then closed while the foot is held in the desired position.

POSTOPERATIVE CARE

A plaster boot or a pressure dressing over padding with application of plaster below the knee has been used in nearly all patients. Although the paster boot has been used in the great majority of cases, a simple pressure dressing has been applied in some, demonstrating that the use of plaster may not be essential in every case. The stability of the foot with internal fixation is such that the application of the postoperative dressing is greatly simplified; in no case have we had displacement of the bone surfaces occur while the dressing was being applied or subsequently in the dressing or plaster. In most cases a plaster boot has been applied immediately, but in no case has the toe-to-groin plaster been applied. In cases where plaster was not used immediately after operation, a plaster boot was later applied before the patient went home, to prevent the possibility of meddlesome change of dressings.

The first postoperative dressing is usually changed after ten to twelve days, at which time the sutures are removed and the plaster boot is reapplied. The weight-bearing heel is applied at various times, depending upon the type of case. Partial weight-bearing with crutches may be started as early as three weeks or as soon thereafter as the condition of the patient permits.

RESULTS

Of the sixty-three foot-stabilization procedures done by us since June 1949, we have been able to follow twenty patients with twenty-two feet operated upon. There has been no loss of life or limb and no serious complications attributable to surgery have occurred in the entire series. There have been no wound infections. Minor skin necroses at the site of operation in a few cases have been approximately equivalent to those encountered in foot-stabilization procedures before the use of internal fixation and bone-chip grafts was adopted. There have been no nerve or vessel complications and there has been no loss of position at any time after operation. All of the joints in the twenty-two feet of twenty patients did fuse in the position in which they were placed at operation. In each instance, the foot has remained in the position in which it was placed at the time of surgery. While the position has not always been perfect, it has been better on the whole in our experience than we were able to obtain prior to the use of internal fixation.

Two patients had persistent pain at the site of operation and the staples were removed after an otherwise good result had been obtained. The pain subsided or disappeared after removal of the staples in both cases. All of the staples have remained in the other twenty feet and none of these patients have returned with any complaint referable to the staples.

FIG. 4-A

Roentgenogram showing drop-foot following poliomyelitis in a girl seventeen years old. No muscles were available for transfer. On June 11, 1951, a Lambrinudi stabilization was done with use of one staple and bone chips.

FIG. 4-B

Roentgenogram made sixteen weeks after the operation showed correction of the drop-foot and bony fusion of the joints.

The patient wore a plaster walking boot for three months after the operation.

ADVANTAGES

The use of metal staples for internal fixation in foot-stabilizing procedures seems to have a number of advantages which cannot be overlooked. In the first place, it probably causes the surgeon to be more meticulous in his surgical procedure than would otherwise be the case. The advantage of precision cutting and trimming of the bone surfaces so that they fit accurately and remain in the desired position for correction of all components of the deformity, to permit the foot to be accurately internally fixed, is obvious. The certainty of maintenance of close, accurate apposition of the resected bone surfaces while the wound is closed and the postoperative dressing is applied, without fear of loss of position of the component parts of the foot, is quite re-

assuring. The use of a pressure-boot dressing or a plaster boot below the knee, instead of a toe-to-groin cast, is preferable for the patient and simpler for the surgeon. The decreased pain and discomfort postoperatively, in most cases, as a result of internal fixation, is quite noticeable. Earlier change of postoperative dressing and removal of sutures than the customary three weeks is obviously advantageous to the patient and decreases hospital time. On the whole, the patients were discharged from the hospital earlier when internal fixation was used.

In our cases, earlier weight-bearing with a snug-fitting plaster boot and crutches has been allowed. Weight-bearing with crutches has been started as early as three weeks in some cases. Early weight-bearing without the fear of displacement of the component in parts of the foot is advantageous.

Although we cannot prove it on a statistical basis, our impression was that the time for solid bony union of all the joints in these twenty-two feet with internal fixation and bone chips was shorter than the time for union in the patients operated upon before the use of this method. The series of patients followed is small; however, the fact that uniform bony fusion occurred in all of the joints of all twenty-two feet is impressive. The period of postoperative immobilization has definitely been shortened in some compared to that before internal fixation was carried out. The earliest discontinuance of plaster immobilization was at the end of seven weeks.

The chief disadvantage of the method, as we have seen it, has been the possible necessity of secondary procedures for removal of staples. This was done in two cases.

1. Patterson, R. L., Jr.; Parrish, F. F.; and Hathaway, E. N.: Stabilizing Operations on the Foot. A Study of the Indications, Techniques Used, and End Results. J. Bone and Joint Surg., **32-A**: 1–26, Jan. 1950.

DISCUSSION

Dr. Walter P. Blount, Milwaukee, Wisconsin: Dr. Alldredge and Dr. Riordan have made an important contribution in emphasizing the value of internal fixation in stabilization operations on the foot. Only if the fragments are maintained accurately in the desired position is it safe to use multiple small bone chips to hasten healing. If bone chips are used without internal fixation, the slightest movement of the reshaped bones may displace the chips and allow them to lock the bones in the wrong position. I have watched some surgeons holding a foot with trepidation while a cast is being put on and having an x-ray made immediately afterward to see if the bones had remained in position.

The use of internal fixation and chips was taught me by F. J. Gaenslen twenty-five years ago and I have not changed the technique since. After the foot has been brought into the desired position, the hind part of the foot is held securely by a spike driven up through a stab wound in front of the heel, securely impaling the calcaneus, the talus, and the tibia. Small crevices between the bones are packed loosely with very small chips. Subsequent pressure on the fore part of the foot in the direction of dorsiflexion and valgus brings the reshaped surfaces together snugly. This technique is particularly valuable in the Lambrinudi type of stabilization. I use it also in astragalectomies.

I have seen no disadvantage in having the pin cross the ankle joint. It is well known that a single small longitudinal pin causes no epiphyseal disturbance. I can recommend the method highly, but I should warn you not to place the pin in the weight-bearing part of the heel where a scar would be painful.

Dr. R. E. Burns of Madison has popularized the use of staples in a great variety of situations. I use them in stabilizing procedures on the foot. If a pin is driven through the heel, one additional staple is valuable in maintaining the correction in cases of extreme flat-foot. With the hind part of the foot in a neutral position, it is difficult to hold the talus and navicular accurately. Displacement of these bones can be eliminated by a single staple placed through a medial incision. This staple is used in addition to the pin. The staple is ideal for holding together two surfaces which are vertical to the long axis of the foot, whereas a spike is more useful in fixing those which are more or less parallel to the sole of the foot.

The advantages of the method are as follows: Accurate internal fixation reduces pressure on the skin; such pressure may be a potential cause of pain and even of slough. With the use of a pin, an occasional staple, and bone chips, the incidence of pseudarthrosis has diminished almost to the vanishing point. The pin is removed with the first change of cast. I have not yet had to remove a staple. In my opinion, it is a mistake to use more staples than are really needed. Dr. Alldredge has already said that he has had to remove a few. I should like to warn that in very soft bones the staples will not hold. The reflexion of skin necessary for placing of the staples increases the likelihood of marginal necrosis.

I cannot close without registering an objection to the implication by Dr. Alldredge that the use of a short cast instead of a long one is all to the good. Again I should like to put in a plea for the use of a long

plaster cast with the knee in flexion during the first few weeks of postoperative fixation. Elevation and packing with ice bags are actually facilitated by the long cast. The immobilization of a knee for a period of five weeks is not a disadvantage in a child. If there is no contra-indication to knee flexion, this position should be used to relax the gastrocnemius, prevent rotation strain, and thus make the patient more comfortable. Staples do not prevent the gastrocnemius muscle from plantarflexing the foot. A spike, on the other hand, securely fixes the heel in its relationship to the tibia. This is an important aid in preventing pressure on the ball of the foot, which has occasionally led to disastrous skin necrosis.

Dr. Alldredge and Dr. Riordan have illustrated a valuable principle of operating technique. You will all be wise to include staples in your armamentarium for foot stabilization. I should like to recommend also nailing the heel as one of the most helpful additional procedures orthopaedic surgery has to offer.

Dr. H. Relton McCarroll, St. Louis, Missouri: The authors have stressed two points in this paper. The first of these has to do with the use of chip grafts at the time of stabilization. This procedure was introduced and used by Dr. Michael Hoke thirty-five years ago, and it is a little surprising to know that Dr. Alldredge and Dr. Riordan first decided to use it in 1949. I had thought it enjoyed universal application and was routinely used in all clinics in this country today. It certainly is advisable and should be used in every instance, even if it is necessary to obtain extra bone from the iliac crest in order to fill the subtalar fossa.

The second point the authors made is with reference to the use of the staples. In our discussion of this, I think there are four points that might be mentioned:

1. First of all, in children, and the majority of these patients were children, is such a step necessary? I do not believe that it is. Our poor results in stabilization of the foot in children between the ages of eight and fifteen do not come from an inadequate position at the time of stabilization or from failure of fusion in these feet, but rather from extrinsic factors which tend to produce recurrent deformities. The use of staples will have no effect on this problem.

2. The second point I would like to mention is that of attempting to re-align and position the foot at the time of the operation. In stabilization procedures the foot should be re-aligned in relation to the ankle joint and the two malleoli and the entire extremity should be taken into consideration. If we are dealing with a small exposed part, it is often very difficult for us to determine the exact position in which the foot should be placed. As a result of this, we frequently find it necessary to close the wound, apply the dressing, and remove all drapes before we know the position in which the foot should be placed. The use of staples at the time of operation precludes any such possibility.

3. The third point has to do with changing the position of the foot if we find it necessary. We would like to believe that at the time of stabilization we can put the foot in the exact position we desire. Unfortunately, that is not always true. At the end of ten days the plaster, dressing, and sutures can be removed. The patient can be given a general anaesthetic and the foot can be molded into a more satisfactory position, if we find it necessary. If we have used staples and have rigidly fixed these joints, that also is impossible. The use of staples, of course, may make it difficult at times to mold a satisfactory longitudinal arch, and the molding of this arch is not an unimportant step at the time this plaster cast is applied.

4. The final point I would like to mention is with reference to pain. Dr. Alldredge said that one of the principal indications for the use of staples is for the control of pain postoperatively, yet in two instances it has been necessary for him to remove the staples in order to relieve the pain at a later date.

I, therefore, do not feel that we are justified at the moment in advising the use of staples routinely in our stabilization work. If they are used routinely, I believe there is a definite possibility that our results ten years from today will be worse rather than better.

Dr. Alldredge (closing): I wish to call attention to the pliers used in putting these staples in. They are pliers which I borrowed from Dr. Blount several years ago and I have never used anything else. Of course, staples and bone chips in surgery are not new and no claim is made in this paper that they are. I think that the use of internal fixation in foot-stabilization procedures is one of the last applications for internal fixation in joint fusions and in other bone surgery. We find that internal fixation has been used and described in the literature by some of our leading surgeons in the following conditions: in spine and shoulder fusions, in elbow fusions, in wrist fusions, and in almost all the fusions of the joints of the fingers. It has been used in hip fusions, although not in all cases; it has been used extensively in knee fusions and fusions of the joints of the toes, but internal fixation in foot stabilization has not been used extensively as far as we know. We do know that many attempts have been made to use internal fixation in foot stabilization with transfixion pins and even sutures across the joints—surgical sutures have been used across the joints for many years. The use of staples and bone chips in surgery is not new, but they have not been used much in foot stabilization.

As to the position of the foot, we too have had to reposition many of them in the past, but we feel that, if the patient is carefully studied beforehand and the required position and alignment are determined, the use of staples obviates the necessity for repositioning the foot in relation to the ankle and leg at a later date.

It should be emphasized that internal fixation is not indicated in all foot-stabilization procedures. It should be carefully selected and applied by the surgeon in the individual case where it is needed and where it will serve a useful purpose.

THE PATELLAR-ADVANCEMENT OPERATION IN CEREBRAL PALSY*

BY W. M. ROBERTS, M.D., AND JOHN P. ADAMS, M.D.†, GASTONIA, NORTH CAROLINA

From the North Carolina Orthopedic Hospital, Gastonia

The indications for surgery in patients with cerebral palsy are limited, but in some patients the utilization of certain surgical procedures will aid greatly in their rehabilitation [4, 7, 8, 9]. The patients who have had patellar-advancement operations (the Chandler procedure) as part of their general rehabilitation program form the basis for this paper.

Chandler credits Waltham with performing a transplant of the tibial tubercle in 1893.

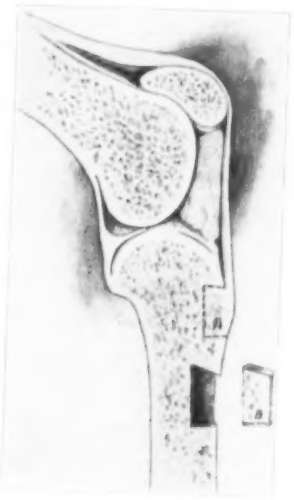

FIG. 1-A

FIG. 1-B

Showing the patellar-advancement procedure as originally presented by Chandler. (Reproduced by permission from *Surgery, Gynecology, and Obstetrics*, 57:524, 1933.)

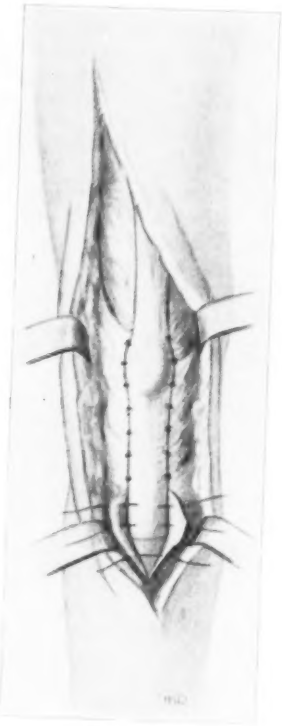

FIG. 1-C

In this instance the pathological condition was a laterally dislocating patella. Transplantation of the patellar-tendon insertion in cerebral palsy was described by Chandler [2] in 1933, together with the rationale of its usage and the surgical technique employed. Figures 1-A to 1-C illustrate the procedure as first described by Chandler and used on these patients, showing the advancement of the patellar tendon with a block of tibial bone to a site distal to the original insertion. Chandler [3] later modified his operation to avoid epiphyseal growth arrest (Fig. 2).

A modification of this procedure which has been used at Duke Hospital [1] is illustrated in Figure 3. The tendon itself is transplanted without a block of bone being removed, the tendon being anchored distally beneath an osteoperiosteal flap by means of a metal screw and silk sutures. The principal advantages of this procedure are transplantation of the tendon without injury to the epiphysis, the technical advantage of an easier technique and therefore shorter operating time, and less postoperative discomfort.

At the North Carolina Orthopedic Hospital, the patellar-advancement operation has

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1953.

† Orthopaedic Fellow, National Foundation for Infantile Paralysis, Inc., Duke University School of Medicine, Durham.

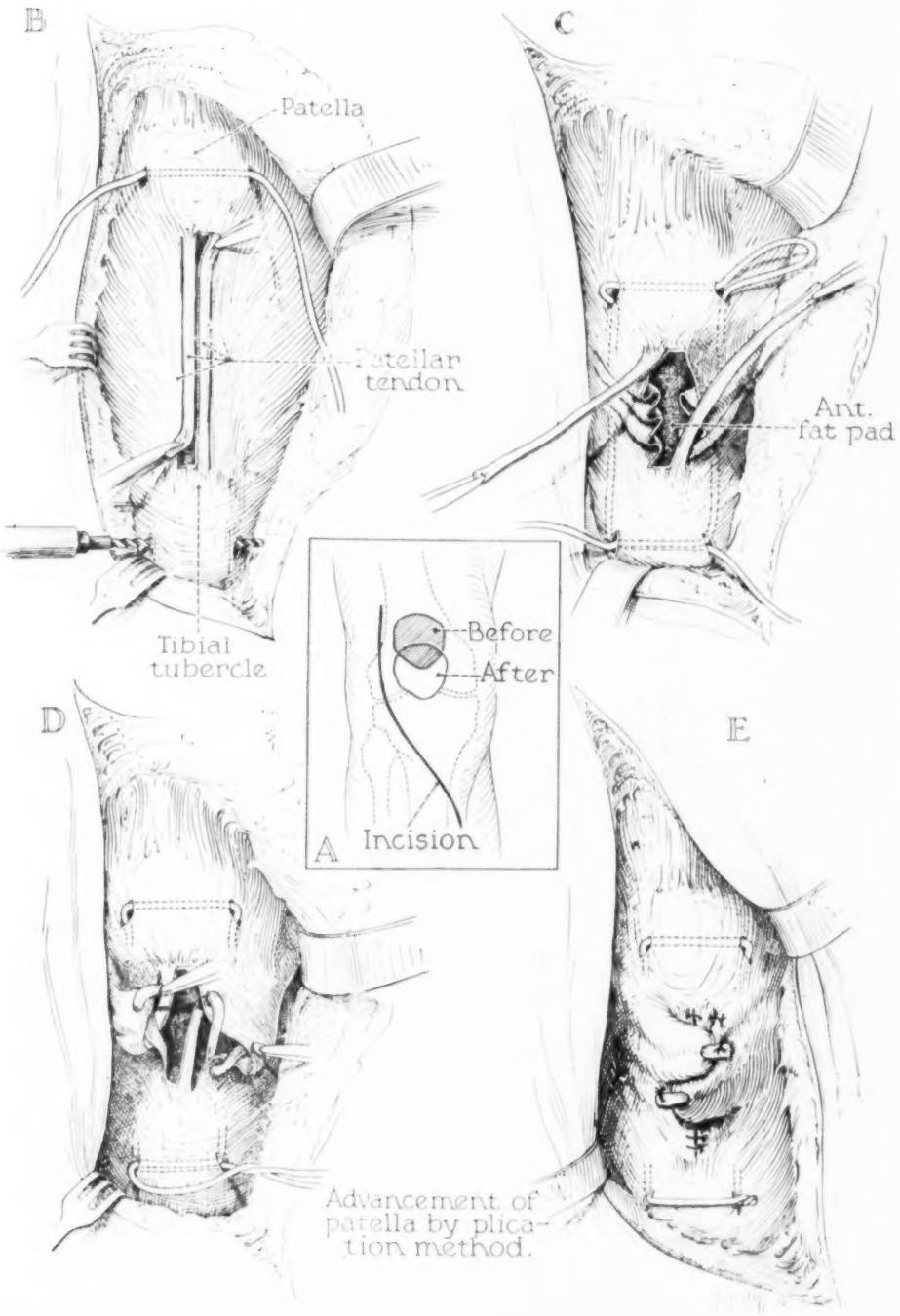

FIG. 2

Chandler's later modification of the procedure. (Reproduced by permission from *The Journal of the International College of Surgeons*, 3: 434, 1940.)

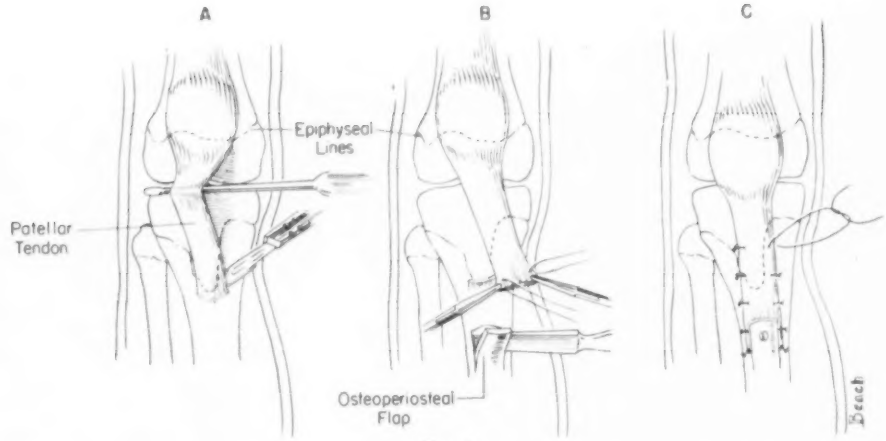

FIG. 3

A: Illustrating the sharp dissection used in freeing the patellar tendon; note the relationship of the tendon to the underlying tibial epiphysis as well as its high-riding position in the preoperative state.

B: Showing the level at which the tendon was sectioned. The osteoperiosteal flap was raised distally to form the site of the new insertion. The corners of the tendon are grasped with an instrument and in addition guy sutures are placed.

C: Illustrating the tendon transferred to its new position and the fixation with a screw and silk sutures. The new relationship of the patella can be seen by comparing its relative position with the distal femoral epiphysis. (Courtesy of L. D. Baker, M. D., Duke Hospital, Durham, North Carolina.)

been performed forty-two times on twenty-one patients. An adequate follow-up has been obtained on sixteen patients. The period of follow-up averaged 6.5 years. All procedures were performed bilaterally.

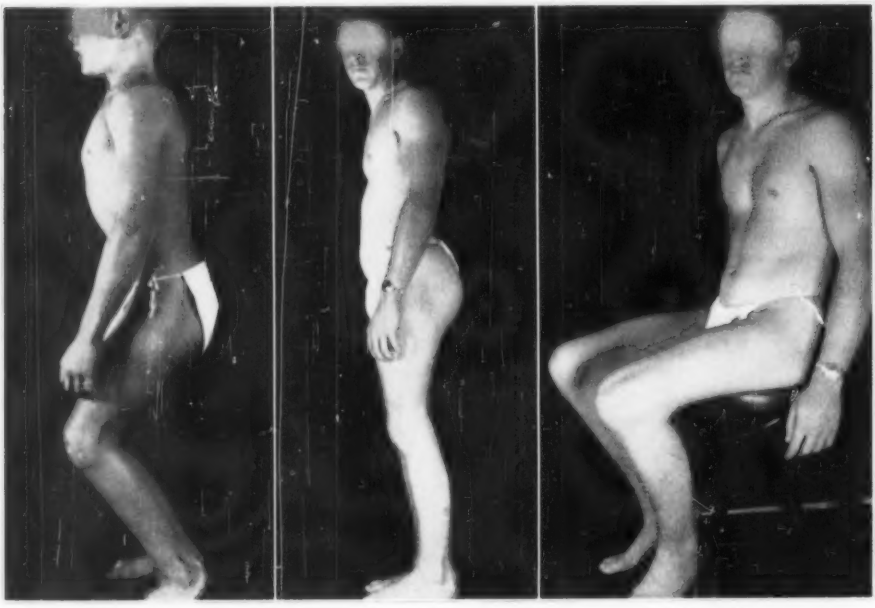

FIG. 4-A FIG. 4-B FIG. 4-C

Fig. 4-A: Showing the degree of extension which the patient could assume preoperatively.

Fig. 4-B: Showing the degree of extension at the follow-up examination.

Fig. 4-C: Adequate flexion was present. The patient was able to engage in athletic activities. The result in this case was rated as excellent.

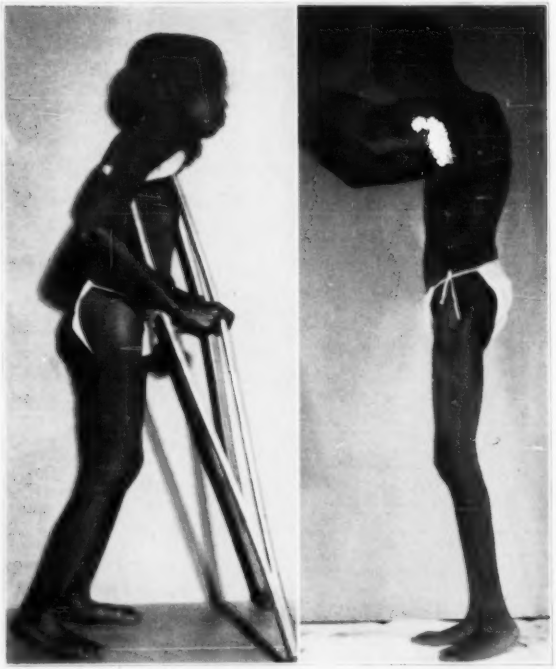

FIG. 5-A

FIG. 5-B

FIG. 6-A

FIG. 6-B

Fig. 5-A: Before operation the patient was unable to extend the knees beyond about 155 degrees and was able to stand only with the aid of crutches.

Fig. 5-B: At follow-up examination the patient was able to rise, walk, and stand alone without difficulty. He would probably have had a better result if the equinus deformity of the foot had been corrected.

Figs. 6-A and 6-B: Showing a postoperative result rated as fair. The patient was able to walk only with the aid of crutches and his knees showed a moderate degree of recurvatum.

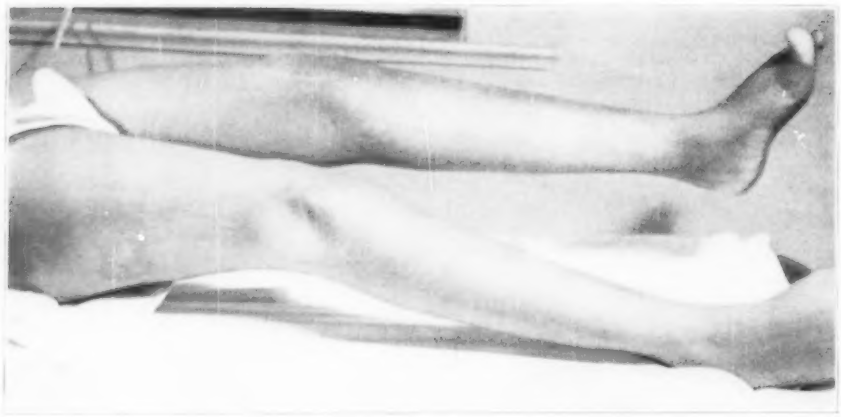

FIG. 7

Showing a postoperative result which was considered to be a failure. The operation increased the range of active extension, but the patient was unwilling to walk because of severe mental retardation.

INDICATIONS

In the selection of patients the general indications for surgery in cerebral palsy must be followed. The patient must be evaluated clinically from the standpoint of mentality, other physical handicaps, and certain social factors which may influence his after-care. The patient's entire program of rehabilitation must be tentatively outlined. As a rule, one group of offending muscles is attacked at a time, and frequent re-evaluations of the patient are common. In those patients in whom multiple procedures are to be carried out, initial attention should be directed to muscle groups in which active function is not of primary importance; for example, adduction deformity of the thighs should be corrected by neurectomy or tenotomy. Equinus deformity, when present, should be corrected by neurectomy or appropriate tendon-lengthening or both. In the correction of contractures, spasticity, or tension states in the triceps surae group, great care must be exercised, as a calcaneus deformity may be produced. A calcaneus type of foot is a great handicap to a patient whose gait pattern is altered from one of flexion to one of extension. Power to fix the knee and ankle posteriorly is a function necessary for attaining and maintaining the extended position. Contractures about the hip, whether they are flexion or adduction contractures, should also be corrected before any procedure about the knee is performed. If knee-flexion contracture is present, it must be overcome before the knee extensor and flexor mechanisms can be adequately evaluated. As a rule, those patients who are good candidates for patellar-advancement procedures should exhibit good or normal quadriceps strength, together with inability to extend the knee

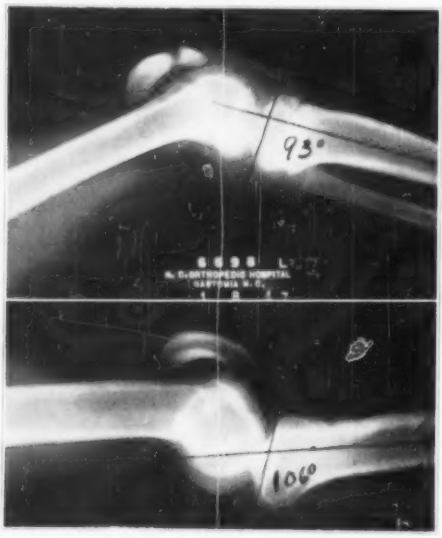

FIG. 8

Roentgenograms showing separation of the patellar fragments. This finding was seen in one additional case and, as in this case, the fragments had united prior to performance of the procedure.

beyond 160 to 170 degrees, and a patella several centimeters proximal to the normal position. These criteria were originally stated by Chandler and this study aims to emphasize their importance.

The relationship between hamstring and quadriceps strength must be established. A differential of one grade, the quadriceps being the stronger, would seem to be the optimum relationship. Hamstring weakening can be achieved by sciatic neurectomy, hamstring tenotomy, or transplanation of the hamstrings [5] into the femoral condyles. This last procedure has not been used in this series. The patellar advancement should be carried out as the last of the surgical procedures.

The postoperative care of these patients is important. Preferably they should be treated in an institution where constant physical therapy is possible. Quadriceps-setting exercises should be begun as soon as postoperative pain has disappeared. At the end of eight weeks the casts are bivalved and the posterior halves are worn when the patient is not actively exercising the knees. If braces are indicated for other reasons, they can be substituted for postoperative plaster splints. Adequate flexion for sitting will be gained without specific flexion exercises. Progressive quadriceps resistance exercises are of value. Weight-bearing in parallel bars is begun as soon as the patient is able to maintain the extended

Fig. 9

Fig. 9: Illustrating recurrence of flexion deformity in a patient whose over-all result was graded as fair. Note the prominence of the hamstring tendons and the wide tendinous insertion of the iliotibial band. The presence of these active and obviously strong muscles has been responsible for the production of this recurrent flexion deformity. Today we would have corrected the overactivity of these muscles both at the hip and at the knee before undertaking the patellar-advancement procedure.

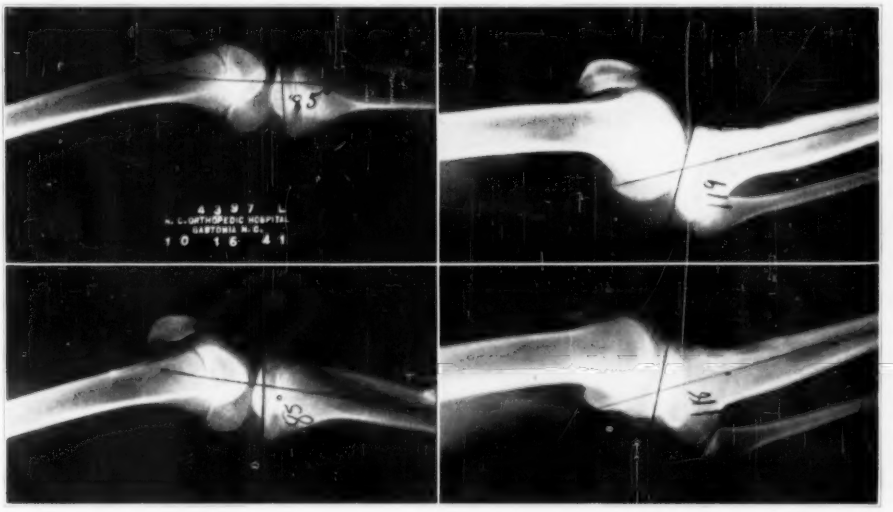

Fig. 10-A

Fig. 10-B

Fig. 10-A: The roentgenograms made in 1941 showed the preoperative relationship of the tibial shaft and the tibial condyle to be in the form of an angle measuring approximately 85 degrees.

Fig. 10-B: Roentgenograms made in 1951 showed the angle to have increased to 119 degrees. The operative site is still obvious. Proximally the operative area would seem to include the anterior portion of the proximal tibial epiphysis. We feel that this complication will be avoided in the future by the modification in the technique.

	NAME	RANGE & STRENGTH (ACTIVE)						PREVIOUS SURGERY				RESULT	YEARS FOLLOW UP	NEUROLOGICAL INVOLVEMENT
			HAMSTRING FLEX.		QUADRICEPS EXTEN.			POP. N.	OBT. N.	SCI. N.	HCL			
1.	B.B.	R	80°	G+	180°	N		X	X		X			QUADRIPLEGIA
		L	80°	G+	180°	N		X	X		X	FAIR	10	
2.	H.C.	R	80°	G+	170°	G-		X	X		X			QUADRIPLEGIA
		L	80°	G+	180°	G		X	X		X	FAIR	11	
3.	C.H.	R	75°	N	165°	N		X			X			TRIPLEGIA
		L	70°	N	175°	N		X			X	GOOD	8	
4.	J.D.S.	R	90°	F+	190°	G+		X	X		X			PARAPLEGIA
		L	90°	F+	190°	G+		X	X		X	FAIR	10	
5.	F.F.	R	100°	F+	130°	G			X			NO		QUADRIPLEGIA
		L	110°	F	160°	F+			X			BENEFIT	10	
6.	T.B.	R	110°	F+	165°	G		X	X	X	X			QUADRIPLEGIA
		L	90°	G	155°	G		X	X	X	X	FAIR	3.5	
7.	J.B.	R	100°	F-	160°	F+		X	X	X	X			QUADRIPLEGIA
		L	100°	F+	155°	G		X	X	X	X	FAIR	4	

CHART I

position. Braces were not used postoperatively in any of these patients, although the use of braces is unquestionably of value in certain cases, particularly in those in which prolonged close supervision is not possible.

RESULTS

The results have been ascertained through the use of the following criteria:

Excellent

1. Ability to walk in full extension without aid;
2. Ability to arise from chair without aid;
3. Ability to extend knee against gravity;
4. Range of knee flexion adequate for sitting.

Good

1. Ability to walk without aid with knees slightly flexed or in recurvatum;
2. Ability to arise from chair without aid;
3. Ability to extend knees against gravity, although the range may be limited;
4. Range of knee flexion adequate for sitting.

Fair

1. Ability to walk alone with aid of crutches;
2. Ability to walk about house without crutches;
3. Ability to arise from chair with aid of crutches;
4. Achievement of ambulatory status in patient previously confined to a bed or wheel chair.

There have been patients in this group who have received no benefit from this procedure. The failures represent primarily poor selection of patients. In these patients the procedure increased the range of active knee extension, but, because of other factors, the patients were unable or unwilling to ambulate.

On the basis of the criteria described the results were as follows: excellent, two; good, three; fair, nine; failures, two. An example of each is represented in Figures 4 through 7 inclusive.

	NAME	RANGE & STRENGTH (ACTIVE)					PREVIOUS SURGERY				RESULT	YEARS FOLLOW UP	NEUROLOGICAL INVOLVEMENT
		HAMSTRING FLEX.			QUADRICEPS EXTEN.		POP.N.	OBT.N.	SCI.N.	HCL			
8.	D.W.	R	60°	G	180°	N	X		X	X			PARAPLEGIA
		L	75°	G-	180°	N	X		X	X	EXCEL.	4	
9.	S.G.	R	85°	G-	170°	G	X	X	X	X			ATHETOSIS
		L	65°	F	175°	G	X	X	X	X	FAIR	4	QUADRIPLEGIA
10.	M.F.	R	135°	P+	165°	G		X	X				PARAPLEGIA
		L	90°	F	155°	G-		X	X		FAIR	2.5	
11.	M.W.	R	135°	G-	190°	G-		X	X				PARAPLEGIA
		L	120°	G-	170°	F+		X	X		FAIR	10	
12.	A.W.	R	60°	G+	145°	G-		X	X				PARAPLEGIA
		L	60°	G+	145°	G-		X	X		FAIR	2	
13.	S.M.	R	80°	F+	180°	G-			X				PARAPLEGIA
		L	80°	F	180°	G-			X		GOOD	1	ATHETOSIS
14.	M.H.	R	80°	G	170°	G		X	X				PARAPLEGIA
		L	90°	G	170°	G		X	X		GOOD	7	
15.	L.S.	R	90°	G	190°	G	X	X	X	X	NO		ATHETOSIS
		L	120°	F+	170°	G-	X	X	X	X	BENEFIT	3.5	QUADRIPLEGIA
16.	F.D.	R	90°	G-	180°	G	X			X			
		L	90°	G-	180°	G	X			X	EXCEL	12	PARAPLEGIA

CHART II

HCL stands for heel-cord lengthening.

The grading of muscle power in patients with cerebral palsy is difficult, and meeting all of the requirements as set up for each grade in flaccid paralysis is not always possible. The power exhibited objectively must be considered of primary importance and the range of joint motion of secondary importance. One unusual preoperative finding was separation of the patellar fragments (Fig. 8). It is possible that this was produced by an overactive quadriceps, as trauma had not occurred.

A summary of the follow-up findings is given in Charts I and II.

COMPLICATIONS

1. *Recurrence of flexion deformity at the knee:* This is, as a rule, the result either of poor evaluation of hamstring strength and failure to reduce it to the desired level or of inadequate postoperative supervision, either through lack of sufficient physical therapy or through inadequate protection by extension splinting (Fig. 9). Recurrence of flexion contracture at the knee can also be the result of failure to recognize flexion contractures of the hip or the presence of a weak triceps surae group with a resultant calcaneus deformity. A patient cannot walk with the knees extended with a fixed flexion deformity of the hip or if strength about the ankle is not sufficient to stabilize the distal portion of the extremity.

2. *Recurvatum of the knee:* This change (Figs. 10-A and 10-B) was produced in the tibia through unequal growth of the proximal tibial epiphysis. This inequality of growth was produced by interference with the anterior portion of the epiphysis at the time of surgery and the added factor of increased pressure [6] to the anterior portion of the epiphysis following the transplantation. Excessive reduction of strength in the hamstrings should always be considered as a causative factor in the production of this deformity. However, this was not of importance in this series.

3. *Fracture of the tibia:* This occurred in one instance at the site of the original patellar insertion; it was the result of removal of more bone than was necessary and will be avoided with the modified technique (Fig. 3).

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DISCUSSION

Dr. Fremont A. Chandler, Chicago, Illinois: Dr. Roberts and Dr. Adams have presented a critical study of the results of the patellar-advancement operation in sixteen cases with an average follow-up period of six and one-half years. They have enumerated the indications and contra-indications clearly and have emphasized the role of this procedure in the rehabilitation of certain cases of cerebral palsy. This operation at best is only the means of removing one of the obstacles to progress in a small number of patients. It does not replace the long-term training which must be followed in these cases. The operation should be undertaken only after careful analysis of all the factors which have been emphasized by the speakers.

The objective of this operation or its modification is the replacement of the patella to its normal anatomical relationship to the knee joint. The constant pull of the powerful extensors of the knee augmented by the flexed position of the knee joint result in elongation of the patellar tendon and upward displacement of the patella. The function of the vastus medialis and the vastus lateralis is impaired; extension of the knee through the last 15 or 20 degrees is lost; and the patient assumes the "jump" position. When the patella is replaced to its normal position, the function of the vastus femoralis is improved. Should the rectus femoralis be so short as to prevent elongation of the extensor muscle group, division of the proximal rectus tendon is indicated.

The necessity of correcting the flexion deformity of the knee should be obvious. The original operation met the needs of the older patients, but the danger of arrest of growth is real in younger patients.

The use of wire combined with plication of the patellar tendon in advancing the patella has not been satisfactory in some cases because of crystallization and breaking of the wire months after surgery. We are now using one-sixteenth inch 18-8, seven by seven airplane cable, in the hope that the fatigue phenomenon so characteristic of stainless steel will be overcome.

If replacement of the patella to its normal position can be accomplished, regardless of the technique, the extensor mechanism of the knee will be enhanced, providing good judgment in the selection of cases has been exercised.

The merits or defects of any surgical principle become more evident by the presentation of such an analysis as has been given by Dr. Roberts and Dr. Adams.

Dr. Charles N. Pease, Chicago, Illinois: The principle of the patellar-advancement operation is sound. However, on the surface, this report would indicate that the procedure is of questionable value.

Long ago I could have presented a follow-up study of the patients originally operated upon at the Children's Memorial Hospital, but the percentage of satisfactory results was about the same as that reported by Dr. Roberts and Dr. Adams; and as I was not the originator of this operation it might have been considered unfair for me to make such a report.

The extensive dissection of the knee joint and insertion of wire loops which were constantly irritating to the synovial membrane, as well as the necessity of a secondary operation to remove the wires, which almost always broke, all produced a not inconsiderable insult to the children's knee joint.

(*Continued on page 970*)

ARTHROPATHY DUE TO ADJACENT INFLAMMATION *

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INTRODUCTION AND HISTORY

Spontaneous atlanto-axial displacement first attracted wide interest in 1930, although sporadic reports of this startling condition had appeared in the preceding literature for over twenty years. Studying the common postinfectious wryneck of children, Berkheiser and Seidler were able to show by roentgenograms that, in certain cases, the torticollis resulted directly from spontaneous subluxation or dislocation at the atlanto-axial joint. Independently, Grisel and Desfosses, of France, published illustrations of the lesion. A large number of case reports were published in England and America after the appearance of these basic papers, confirming their findings; by 1934, Watson-Jones had personally collected twenty-one cases. At the present time, the diagnosis is no longer rare and would be still more frequent were it not for the technical difficulties of its demonstration. According to Brailsford, Kleinhaus pointed out that simple subluxation is practically impossible to recognize on roentgenograms made with the patient's neck in the torticollis position. On the other hand, manual correction of the torticollis in order to obtain an accurate anteroposterior roentgenogram serves also as a reduction manoeuvre and may completely mask an existing minor displacement.

Identification of the true underlying lesion in these cases was of far more than therapeutic value. Most significant was the first clear demonstration that even a small and discrete hyperaemic focus could weaken a neighboring joint structure to the point of dislocation without provocative trauma.

What is the mechanism of the production of this bizarre arthropathy? Does it occur only at the atlanto-axial level or do equivalent disturbances develop in other joints as well? Is the phenomenon related to the joint disturbances which have been demonstrated to be a result of rheumatoid spondylitis [10]? Subsequent literature has contributed little to the solution of these problems, and the mechanism of the process is still unclarified. Only vague references in the literature hint that equivalent phenomena may occur in other locations.

The present study postulates that joint displacement due to adjacent inflammation is in no sense a specific affection of the atlanto-axial joint, but rather that it is a disturbance which develops at several skeletal locations. In the spine, joint displacement due to adjacent inflammation may be recognized at various levels, and its role in the pathogenesis of several common arthropathies of the spine appears to be significant.

CLINICAL BEHAVIOR

A clear picture of the characteristics of the lesion of the atlanto-axial joint is helpful in recognizing the counterpart of this condition in other locations. A few of the clinical attributes of the phenomenon as observed in the literature and in our own cases may be summarized as follows:

1. *There is no typical time schedule or clinical pattern:* Dislocation has been noted as early as twenty-four hours after simple tonsillectomy [12] or as late as many years after onset of indolent cervical-node enlargement.

2. *There appears to be no detectable relationship with the severity or intensity of the*

* Read at the meeting of the Orthopaedic Section of the New York Academy of Medicine, New York, N. Y., March 21, 1952.

inflammatory process: Berkheiser recently reported that in one year he had seen three instances of dislocation after simple tonsillectomy. On the other hand in many severe and protracted throat infections, no evidence of this complication develops. (This has led to the general impression that some *X* factor must be involved.)

3. *Of significance is the fact that the condition may constitute a response to either a primary neighboring focus or a remote focus draining into lymph nodes which lie close to the joint:* Infections of the middle ear, osteomyelitis of the cranial vault, sinusitis, and root abscesses are examples of conditions which have produced arthropathy through the intermediary of the cervical nodes draining remote primary foci.

4. *The condition generally starts suddenly during or shortly after the subsidence of the original focus:* Usually the patient has the sensation that something in the neck has yielded. Premonitory symptoms are rare.

5. *Pain may vary from mild discomfort to great agony:* The most common complaint is of neck deformity.

6. *A final noteworthy property of these lesions is their remarkable ability to heal firmly after reduction and immobilization even when the causative inflammatory focus continues unabated.*

MECHANISM

There is no precise knowledge concerning the mechanism of the production of this type of arthropathy. The casual explanation of Grisel that excessive suboccipital muscle spasm might overcome joint resistance is untenable. In most instances, these dislocations occur suddenly and are not preceded by neck spasm or by torticollis. It must be assumed, therefore, that the dislocation is the result of ligament weakness so marked that the structure can no longer withstand normal strain.

Berkheiser believed that such ligamentous relaxation is through the intermediary of arthritis of the intervertebral joints as a result of direct lymphatic spread from the original focus. The displacement, however, generally appears suddenly and is not commonly preceded by symptoms of arthritis.

Both Watson-Jones and Greig are strongly of the opinion that secondary hyperaemic bone atrophy is responsible for the weakened hold of the ligaments at their attachments. According to Greig "the ligaments about the vertebrae throughout the whole vertebral column are so strong and powerful that they cannot be avulsed without tearing off with them fragments of the bone to which they are attached as attempts in the post-mortem theatre or dissecting room will easily verify. If the bone has undergone previous decalcification the ligaments yield readily." Although the correctness of this observation may be easily confirmed, it does not necessarily indicate that the ligaments pull out of the bone as Greig believed. The independent weakness of the ligament may be greater than that of the skeleton, and the ligament may tear at the point of attachment without pulling a bone flake free.

LABORATORY STUDY

The speed with which joint ligaments can weaken in response to neighboring inflammation may be readily demonstrated in animals. In laboratory studies being conducted at present, a simple technique has been evolved to determine the influence of pyarthrosis of the knee upon the breaking strength of the tibial collateral ligament in rabbits. Aseptic pyarthrosis is induced with turpentine. The tibial collateral ligament is utilized because of the relative ease with which it may be cleanly dissected and because it is seldom directly involved in the inflammatory disturbance. At varying periods after the induction of unilateral knee pyarthrosis, the animals are sacrificed and both hind extremities are removed and are prepared for testing. The knee of the well extremity serves as control. The specimen for testing consists of the lower portion of the femur

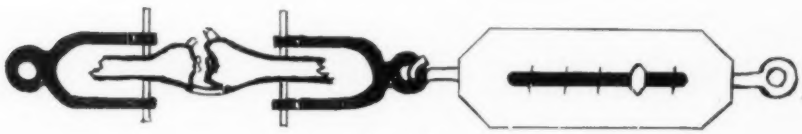

FIG. 1-A

Diagram of the tension apparatus used in the experimental study.

Rabbit No.	Pyarthrosis Side	Pyarthrosis Duration	Breaking Strength Right	Breaking Strength Left	X-ray for Bone Atrophy
#315	Rt. Knee	14 days	24 lbs	45 lbs	
#376	Rt. Knee	14 days	20 lbs	37 lbs	

FIG. 1-B

Illustrative examples of ligament weakness associated with pyarthrosis of two weeks' duration are shown. Roentgenograms show absence of bone atrophy.

bound to the upper portion of the tibia by the tibial collateral ligament only,—all other connecting elements having either been removed or severed. The prepared specimen is then mounted in the tension apparatus (Fig. 1-A) by Kirschner wires, and gradual tension is applied until rupture occurs. If care is taken to avoid rotation or angulation of the bone elements, a reasonably accurate reading may be obtained as is indicated by control studies upon uninjected rabbits. Although the details of these experimental studies will be reported separately at a later date, certain findings may be summarized here:

1. On the control side, a flake of bone is consistently torn free with the ligament in accordance with Greig's postmortem observations.

2. On the side of the pyarthrosis, the ligament frays and tears distal to its femoral attachment and no bone flake is torn free.

3. A sharp decline in breaking strength of the tibial collateral ligament develops on the side of the pyarthrosis (Fig. 1-B).

4. This ligament weakness may reach a marked degree before evidence of bone atrophy appears on the roentgenogram (Fig. 1-B).

These studies show the dramatic speed with which joint ligaments may weaken in response to a neighboring inflammation, long before skeletal decalcification reaches a level detectable by roentgenograms. In our specimens, the weakened ligaments seemed to fray and to tear close to the point of attachment—not to pull out of the bone as Greig suggested. The weakness, therefore, appears to be directly in the ligament, coincident with, and not the result of, bone atrophy. This concept is supported by clinical experience with the rarifying bone diseases. Although infraction and fracture are common in osteoporosis and distortion of bone is common in osteomalacia, the ligaments seem to retain a firm hold. In such conditions, sprain, dislocation, or disc disruption occur with no unusual frequency. Further studies on this subject are in progress.

Although for the present the precise explanation of ligamentous fragility caused by neighboring inflammation remains obscure, the phenomenon is undoubtedly a real one and offers a plausible explanation for spontaneous atlanto-axial displacement.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Case 1. P. McK. Subluxation at the second and third cervical interspaces due to adjacent inflammation in a child of three.

Fig. 2-B: Roentgenogram made three months later shows correction to have been obtained after treatment by hyperextension collar.

FIG. 3

Fig. 3: Roentgenogram shows residual deformity in an adult resulting from unrecognized and untreated subluxation due to adjacent inflammation in early childhood.

THE CERVICAL LESION IN CHILDREN

The atlanto-axial joint of the child is especially susceptible to a disturbance caused by adjacent inflammation. Mechanically the atlanto-axial joint dislocates more easily than do the lower cervical articulations. Traumatic cervical dislocations are most common at the atlanto-axial level [4], and execution by hanging is an excellent example of the particular vulnerability of this articulation. In children, this vulnerability is further augmented by the location of the joint in the center of potentially infected soft tissue—the pharynx and tonsils anteriorly and large clusters of cervical nodes laterally. Even in children, however, anatomical variations can alter the involved level as the following example indicates:

CASE 1. P. McK., aged two years, was seen because of gradual shortening of the neck, fixation of the head, and pain when the neck was moved. The condition had existed for about two months and was of gradual onset. No history of trauma was obtained. Prior to onset, however, several months of severe and repeated upper respiratory infections had been present. On examination, several swollen and tender cervical nodes were palpable bilaterally. The roentgenogram (Fig. 2-A) shows the subluxation which was originally present at the second and third cervical interspaces. The final reduction which was obtained after overcorrection in plaster for several months is shown in Figure 2-B.

Unless such subluxation is corrected it can persist permanently as is shown in the roentgenogram (Fig. 3) of an adult cervical spine. The deformity in this instance followed an early childhood illness with no known trauma.

FIG. 4-A

FIG. 4-B

Case 2. M. K. The extent of the lesion is best demonstrated on roentgenograms when the patient's neck has been placed in the Watson-Jones position of full forward flexion.

Fig. 4-A: Roentgenogram made with patient's neck in neutral position shows the buckle.

Fig. 4-B: Roentgenogram made with patient's neck in the position of full forward flexion reveals the loss of parallelism of the facets and the disc narrowing.

FIG. 5-B

FIG. 5-A

Case 3. S. S. Healing of the simple lesion.

Fig. 5-A: Subluxation at the fifth cervical vertebra which occurred two weeks after an attack of severe bronchopneumonia was treated by means of a plaster collar.

Fig. 5-B: Roentgenogram made at follow-up examination sixteen months later shows disc destruction and partial bridging between the involved vertebral bodies. A slight buckle remains. The patient has been totally asymptomatic for one year.

FIG. 6-A

FIG. 6-B

FIG. 6-C

Case 4. H. F. Involvement of several levels with recurrence.

Fig. 6-A: Sudden subluxation of the fourth cervical vertebra while the patient was convalescing from a severe sore throat.

Fig. 6-B: Sore throat and pain in the neck recurred four months later. Subluxation involved the fourth and fifth cervical vertebrae.

Fig. 6-C: At examination five years later, the patient complained of occasional pain in the neck. Roentgenograms showed residual narrowing at the fourth and fifth cervical vertebrae.

THE CERVICAL LESION IN THE ADULT

Although spontaneous displacement of the atlas upon the axis has been described in adults [13], an arthropathy which appears to be the adult equivalent of this lesion may be observed far more commonly at a lower cervical level. To the present, little attention has been devoted to this important lesion in the literature, which reflects the effect of ligamentous relaxation upon a joint of different design in the adult. The usual sites of involvement in the adult are the third, fourth, and fifth cervical interspaces, the descent in level probably being accounted for by the relative descent of the cervical nodes during growth. These cervical levels are well located for careful clinical study; for the superficial neck structure renders primary infection, involved nodes, and spinal joints accessible for accurate examination. In this area, the relationship of infection, ligamentous failure, and arthropathy may be as clearly elicited as at the atlanto-axial plane. The cases to be reported are all non-traumatic in

Fig. 7-A

Fig. 7-B

Case 5. M. E. Sequential involvement of adjoining cervical interspaces.

Fig. 7-A: Original buckle at the fourth cervical vertebra. Symptoms were of two weeks' duration and were associated with a persistent cough and pansinusitis. The symptoms were of short duration.

Fig. 7-B: Ten months later there was recurrence of respiratory infection and pain in the neck. Roentgenogram shows recurrent buckle at the fourth and fifth cervical vertebrae and marked disruption of the disc at the fifth cervical vertebra.

origin and, in each instance, the condition developed in association with neighboring soft-tissue inflammation. Examples were selected to illustrate the difficult behavior of the lower cervical lesion as compared to that of the atlanto-axial level.

The Extent of the Lesion is Best Demonstrated by the Use of the Watson-Jones Position

Case 2. M. K., a man, forty-two years old, suffered several weeks of pain in the neck and pain in the right forearm, hand, and fingers, associated with numbness and tingling. Symptoms developed one week after a severe "cold" and were increasing in severity. There was no preceding trauma. Findings included enlarged and tender mid-cervical nodes and loss of right triceps reflex. A roentgenogram (Fig. 4-A) revealed subluxation at the fifth cervical vertebra, but a roentgenogram (Fig. 4-B) made with the patient's neck in the position of full forward flexion was required to demonstrate the disc narrowing and the loss of parallelism of the facets at the involved level.

Occasionally Bony Healing May Result in Cure at the Involved Level

Case 3. S. S., a man, thirty-three years old, was seen because of severe pain in the neck, right shoulder, and upper portion of the arm. The pain had developed a few weeks previously without trauma, two weeks after an attack of severe bronchopneumonia. Marked fixation of the neck was present as were diffuse tender and enlarged cervical nodes. A roentgenogram (Fig. 5-A) revealed subluxation at the fifth cervical interspace. Pain was relieved by plaster immobilization with the neck in neutral position; one month later some correction of the subluxation was apparent. Convalescence was smooth and pain did not recur. When the patient was seen for another condition sixteen months later, a roentgenogram (Fig. 5-B) showed disc destruction, bridging between the involved vertebral bodies, and a small residual buckle.

Multiple Involvement of Adjacent Interspaces

Case 4. H. F., a woman, thirty years old, complained that "half her life" had been spent with recurrent colds and upper respiratory infection. While convalescing from a sore throat, she was getting dressed when something in her neck "slipped". Within twelve hours pain had become agonizing. Bed traction yielded relief, but roentgenograms made one week later still showed subluxation at the fourth cervical interspace (Fig. 6-A). Four months later another upper respiratory infection re-activated the pain in the neck, and

FIG. 8-A

FIG. 8-B

Case 6. F. L. Involvement at three cervical levels. Sudden spontaneous subluxation, associated with diffuse, enlarged, and tender cervical lymphadenopathy of undetermined etiology, was treated in a foreign country.

Fig. 8-A: Roentgenograms made on the patient's arrival in this country three months later revealed subluxation of the fourth cervical vertebra and narrowing of the disc at the fifth cervical vertebra.

Fig. 8-B: At examination one year later, pain and lymphadenopathy had disappeared. Roentgenogram shows residual narrowing at the fourth, fifth, and sixth cervical vertebrae.

roentgenograms made at this time showed subluxation at both the fourth and fifth cervical levels (Fig. 6-B). Roentgenograms made five years later demonstrated residual narrowing of both disc spaces (Fig. 6-C). Mild attacks of pain in the neck of short duration have continued.

Sequential Involvement of Adjacent Interspaces

Case 5. M. E., a man, twenty-four years old, had a history of longstanding sinusitis, cough, and enlarged tender cervical nodes. Sudden onset of "stiff neck" brought increasing pain for two weeks; there was no radiation of the pain. The patient had a persistent cold with temperature of 102 degrees. A roentgenogram (Fig. 7-A) showed a buckle at the fourth cervical vertebra. Complete relief was obtained after three weeks of rest and treatment with a Schanz collar. Roentgenograms indicated no residual buckle. Ten months later, there was a recurrence of acute upper respiratory infection and of pain in the neck. A roentgenogram (Fig. 7-B) made at this time showed a recurrent buckle at the fourth and fifth cervical vertebrae and marked thinning of the fifth cervical interspace. For the past three years the patient has been asymptomatic.

Multiple Involvement of Adjacent Levels

Case 6. F. L., a prison-camp refugee, forty-six years old, arrived in this country wearing a plaster neck support. Prior to his leaving Germany, severe pain in the neck had developed spontaneously and the diagnosis of dislocation had been made. On removal of the plaster, diffuse cervical lymphadenopathy was disclosed and a roentgenogram (Fig. 8-A) showed a buckle at the fourth cervical vertebra and disc narrowing at the fifth cervical vertebra. Almost one year later, the subluxation and lymphadenopathy had disappeared, but the narrowing of the discs at the fourth, fifth, and sixth cervical vertebrae remained (Fig. 8-B).

COMMENT

Cases such as these are far from uncommon and show the tendency toward the lower cervical response in adults as clearly as the atlanto-axial response may be demonstrated in children.

The characteristic response of the lower cervical joints differs in certain respects from

that observed at the atlanto-axial plane. For example, spontaneous frank dislocation is not encountered at the lower cervical levels. The subluxation observed is moderate and is sometimes so slight as to require the patient's neck to be placed in the Watson-Jones position of full flexion for its roentgenographic demonstration. Reduction is easily obtained and may usually be anticipated without resorting to hyperextension or even plaster immobilization.

Another more important difference is observed in the independent susceptibility of the disc structure which appears at the lower cervical levels. It is not difficult to appreciate that the annular attachments, subject as they are to constant nuclear pressure, might succumb to weakness caused by neighboring inflammation as readily as do the major joint ligaments. The almost invariable accompaniment of disc narrowing with subluxation and the occasional occurrence of disc destruction without subluxation at lower cervical levels suggest that the disc is even more vulnerable to neighboring inflammation than is the joint complex as a whole. The altered architecture of the lower cervical joints, therefore, is responsible for an arthropathy of very different nature. While at all levels these disturbances are clearly the result of ligament failure, the atlanto-axial joint is not destroyed by the lesion and is amenable to complete restitution, an outlook which is impossible at lower cervical levels. Once the disc lesion has been sustained, the structure is permanently compromised and is prone to inevitable further deterioration and often to recurrent, lasting, or even increasing symptoms.

THE LUMBAR LESION

The evidence that neighboring inflammation can precipitate cervical-disc lesions in the adult leads directly to an inquiry concerning the possibility of an equivalent relationship at other levels of the spine. Of particular importance is the possible implication of this mechanism in the pathogenesis of the common disc lesion in the lumbar spine, the etiology of which is still obscure. The depth and concealment of the involved structures at these lower levels render direct demonstration of such a relationship far more difficult than that in the cervical area. Considerable indirect evidence, both anatomical and clinical, indicates that the ligaments of the joints of the lower portion of the lumbar spine may weaken in response to nearby infection as do their cervical equivalents.

Anatomically the lymphatic drainage pattern of the lower portion of the lumbar spine roughly parallels that of the mid-cervical region. The large lumbar nodes which drain all the structures of the perineum and lower extremities and important elements of the pelvic contents lie about the great vessels at their point of division directly anterior to the lower lumbar articulations. Dissections generally demonstrate high concentration in direct proximity to the fourth and fifth lumbar levels. Although concealed by a heavy overlay of tissue, it may be safely inferred that these nodes reflect the frequent and often persistent infections of the tissues which they drain. For this reason, the fourth and fifth lumbar articulations are in a vulnerable location as far as the possibility of response to genitourinary, gynecological, rectal, perineal, or lower-extremity infections is concerned. Other types of lymphadenopathy might also jeopardize these important articulations. Although the depth of the lumbar nodes renders clinical detection of their inflammatory status difficult or impossible in the individual patient, a wealth of clinical experience indicates the frequent association of low-back symptoms with primary inflammatory disturbances which involve the structures draining into these nodes. The frequency with which this relationship is identified rests in large measure upon the thoroughness of the taking of the history and the making of the examination and the extension of these beyond the usual orthopaedic limitations.

The case herewith reported is illustrative of this point and indicates clearly that even massive and deeply buried articulations may succumb to the phenomenon.

CASE 7. D. K., a man, seventy-four years old, vigorous and fond of horseback riding, was seen because of limp and increasing pain in the left low-back region and over the symphysis. The symptoms dated from a

FIG. 9

FIG. 10

Fig. 9: Case 7. D. K. Sacro-iliac and symphyseal separation on the left of non-traumatic origin after over six months of biweekly injection of sclerosing solution into hydrocele.

Fig. 10: Case 8. C. G. Patient gave a history of incapacitating low-back pain associated with bilateral sciatic radiation. The onset followed three illegal interruptions of pregnancy, two of which were followed by severe, prolonged, and nearly lethal pelvic infection.

horseback ride two weeks previously, in the course of which he felt that something had suddenly yielded in the region of the pelvis. No history of trauma could be elicited. The horse had not stumbled. He dismounted with assistance and found walking possible only with great pain and difficulty. Subsequent x-rays disclosed a wide pelvic separation of the symphysis and the left sacro-iliac joint (Fig. 9).

Even after trauma, pelvic separation without fracture is most unusual in an elderly man. Its spontaneous occurrence could result only from abnormally severe ligamentous weakness. In this instance, the clue to the ligamentous failure lay in the fact that the patient had been treated for severe left hydrocele for over six months by biweekly injections of an irritating sclerosing solution.

The clinical files of orthopaedic surgeons are replete with examples of low-back and

sciatic symptoms originating without trauma after pelvic surgery, after genito-urinary, pelvic, and rectal infections, as well as after illnesses which involve generalized lymphadenopathy. Roentgenograms in such cases often reveal recent lumbar-disc narrowing which later results in the arthritic changes and sclerosis of older lesions. Characteristic of the articular response at lumbar levels is the comparative rarity of subluxation of the entire joint, the brunt of the disruption being borne by the integral disc structure. This pattern, as is clearly revealed in Case 8, is in line with common experience.

CASE 8. C. G., a woman, forty-five years old, presented a twelve-year history of incapacitating backache and attacks of sciatic radiation into both lower extremities. The excessive articular damage (Fig. 10) impelled a particularly careful exploration of the history during which the patient reluctantly admitted to having had three illegal abortions during the few years prior to onset of back symptoms. Two of these operations had been followed by severe, prolonged, and nearly lethal infection.

Occasionally, subluxation of the joint as a whole accompanies the disc disruption and the response characteristic of the cervical spine is reproduced as in Cases 9 and 10.

CASE 9. M. T., forty-nine years old, had suffered severe generalized lymphadenopathy and polyarthritis seven years before during which backache began. Roentgenograms of the lumbar spine revealed no notable abnormality. Several years later, roentgenograms were again made because of persistent pain and showed the subluxation seen in Figure 11. The pedicles were intact. A cure was achieved by fusion.

CASE 10. R. K., fifty-one years old, was originally seen in 1937 because of mild symptoms of arthritis in the right knee of many years' duration, suddenly increasing rapidly. The diagnosis of tuberculosis of the knee was proved and arthrodesis of the joint was performed. Three months after the operation, low-back pain developed and shortly thereafter intermittent bilateral sciatic radiation. These symptoms persisted for fourteen years with varying intensity. Roentgenograms (Fig. 12) disclosed severe subluxation of the fourth lumbar vertebra on the fifth lumbar vertebra with marked osteo-arthritic changes of the involved level. The pedicles were intact.

FIG. 11

FIG. 12

Fig. 11: Case 9. M. T. Patient presented a history of severe rheumatoid polyarthritis and generalized lymphadenopathy seven years before he was seen. The severe backache had been interpreted as a manifestation of arthritis and the original roentgenograms of the lumbosacral spine made at the time were negative. Because of persistent low-back pain seven years later, new roentgenograms of the lumbosacral spine were made and the subluxation was disclosed.

Fig. 12: Case 10. R. K. Patient presented longstanding and indolent tuberculosis of the knee. Low-back pain began three months after an arthrodesis of the knee had been undertaken, but roentgenograms of the low back were not made until several years later. Subluxation of the fourth and fifth lumbar vertebrae was shown.

The clue to these phenomena is disclosed in the more accessible mid-cervical lesions. There can be little doubt that, like the atlanto-axial ligaments of children and the cervical ligaments of adults, the ligaments of the lumbar joints may also weaken and yield in response to neighboring inflammation. As it has already been noted in the cervical area, the articular response of the lumbar spine to adjacent inflammation is not inevitable and the complete integrity of the spinal ligaments may be preserved even in the presence of long-sustained and severe pelvic infection.

COMMENT

The thesis that the lumbar articulations may respond with increased vulnerability to neighboring inflammation, as herewith submitted, may have an important bearing on our knowledge of the pathogenesis and prophylaxis of the common lumbar-disc syndrome. Remarkable in this connection is the correspondence in the levels of the lymph-node clusters that drain the commonly infected orifices of the body with those spinal levels most commonly afflicted with disc disturbances. The interpretation of this coincidence must take into account the proclivity of the once damaged disc to continue retrogressive changes and to manifest increasing and lasting symptoms of mechanical origin. For this reason, the pathogenesis of the relatively silent but more important initial lesion may become overshadowed and obscured.

The re-introduction of infection as a factor in the pathogenesis of these overtly mechanical conditions can account for a number of presently unexplained aspects of their development.

Coventry has stated on the basis of his disc studies that the lumbosacral and cervical regions are most susceptible to the aging process,—to the degenerative changes which "cause man's aches and pains in later life". These changes he attributed largely to man's assumption of the orthograde instead of the quadruped posture. It is difficult to perceive how this postural change can materially alter the stresses upon the cervical area. Moreover, disc changes equivalent to man's have been demonstrated in the lumbar spine of quadrupeds [9]. It is particularly difficult to reconcile these widely accepted interpretations with the selective, rapid, and premature disc collapse at certain specific levels while gross integrity is preserved at neighboring levels—levels of practically identical structure and subject to equivalent stress. Equally puzzling clinically is the sudden precipitation of sciatica by the performance of a simple movement previously accomplished countless times without harmful consequence. Problems such as these are not amenable to simple mechanical explanation but can readily be accounted for on the basis of localized and temporarily increased vulnerability, the result of an episode of nearby inflammatory disturbance.

It would appear that in addition to trauma, to wear and tear, and to the aging process, the clinician must also consider the possibility of vulnerability due to adjacent inflammation. Perhaps enough evidence supports this concept to justify a few simple prophylactic measures. Particularly now that the case against long-term bed rest has become so clear, periods that carry with them the risk of increased vulnerability of the low-back structures must be recognized and respected. During and after relevant illnesses, which include generalized lymphadenopathies, obstetrical experiences, gynecological and genito-urinary infections, and after surgery, low-back support and careful guidance of activity are indicated. Irreversible disc damage may be the penalty of an inadequate convalescence and recuperative period.

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DISCUSSION

The Patellar-Advancement Operation in Cerebral Palsy

(*Continued from page 966*)

Neither is the technique which has been described today ideal, as the removal of the patellar tendon at its insertion without the utmost care may result in arrested growth of the tibia, as it did in one of the cases presented. There is a possibility that a longer follow-up of these patients may show additional premature ossification of the anterior portion of the epiphyseal plate.

Criticism in itself without an alternative procedure would be unjust; a simple and safe method is therefore offered.

A transverse incision is made in the infrapatellar region. The patellar tendon is split longitudinally so that two narrow strips in the middle are detached, one above and the other below. These are later used for plication, being woven into the intact portions of the remaining patellar tendon. One threaded wire is inserted transversely through the patella and another is driven into the upper portion of the tibial shaft.

Kirschner bows are attached to each of the wires and are approximated and fastened by pliable stainless-steel wires. The patellar tendon is then plicated to take up the slack, silk being used for suturing.

After the incision has been closed, a toe-to-groin cast is applied; the threaded wires are incorporated in the plaster and the bows are removed.

At the end of four weeks the cast and wires are removed. This is followed by physical therapy consisting only of active use and in some cases of gait training.

Dr. Adams (closing): I wish to thank Dr. Chandler and Dr. Pease for their comments. I would like to point out one thing in answer to Dr. Pease — in all of these cases the procedure as originally described by Dr. Chandler was used. We did not intend to leave the impression that we thought this operation was a failure, but rather that it was quite a good one in certain selected cases. We attempted to point out some of the errors we had made and to show why good or excellent results were not obtained in most cases.

AN EXPERIMENTAL STUDY OF THE USE OF GELFOAM TO FILL DEFECTS IN BONE *

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In 1934, Key, in searching for an artificial medium which would act as a bridge for bone repair, stated: ". . . if a defect in bone could be filled by a non-irritating, slowly soluble mass, which was porous and which contained calcium phosphate and carbonate in a form in which they could be resorbed, it would be reasonable to expect osteoblasts to invade the mass, utilize the calcium, and build new bone which would replace the mass of calcium and cause the bone to be restored to its original form". His experiments showed that with the material which he used this did not occur.

Recognizing the difficulty of obliterating large defects in bone resulting from injuries, as observed during World War II, we wondered if gelfoam might not be a suitable medium.

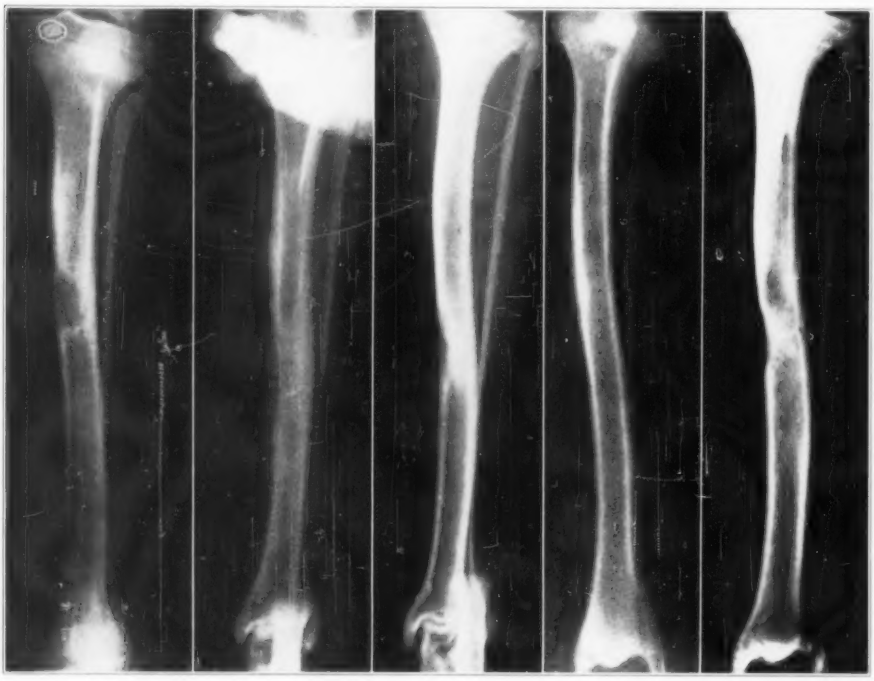

FIG. 1-A FIG. 1-B FIG. 1-C FIG. 1-D FIG. 1-E

Five examples of crater-type defects in the tibia are shown here at varying intervals.

In Fig. 1-A the defect had been filled with experimental gelfoam with calcium salts; this x-ray was made four weeks after operation.

Fig. 1-B shows a control tibia, x-rayed six weeks after operation.

In Fig. 1-C experimental gelfoam without calcium salts had been placed in the tibia; this x-ray was made at seven weeks.

Fig. 1-D shows a tibia of a dog sacrificed fifteen weeks after a crater had been filled with experimental gelfoam with calcium salts.

Fig. 1-E shows a tibia eighteen weeks after the defect had been filled with ordinary commercial gelfoam soaked in a suspension of calcium salts.

* Presented at the Surgical Forum, Clinical Congress of the American College of Surgeons, New York City, September 24, 1952.

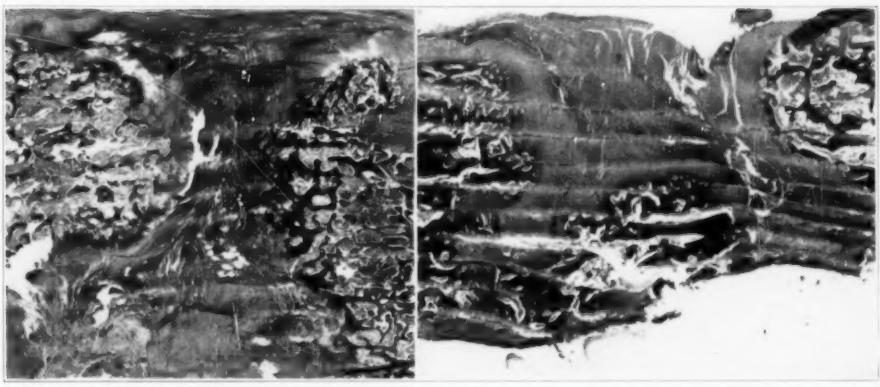

FIG. 2-A FIG. 2-B

Low-power photomicrographs of the pseudarthrosis present in each radius of a dog sacrificed twenty-four weeks after removal of a segment. The defect in the right radius was packed with gelfoam (Fig. 2-A) and the left radius (Fig. 2-B) was the control. In this case each ulna remained intact.

It has been shown by Correll and Wise and by Light and Prentice that gelfoam, when placed in soft tissues, is a non-irritating absorbable substance, and that it is completely or almost completely absorbed in thirty days. Furthermore, it is a porous mass which can easily be invaded and be replaced. In fact, we felt that it was too readily absorbed to suit our purpose. For this reason experimental material (8581–5) † was also used.

In order to ascertain the reaction of this material in the tissues, a series of experiments was done in dogs. Using the rectus abdominus muscle as a bed, we inserted ordinary commercial gelfoam on one side and the experimental product 8581–5 on the other. With separate incisions, five pieces of gelfoam were buried beneath the rectus sheath on one side and five pieces of the experimental product 8581–5 on the other side, and these were removed at two-week intervals for microscopic study; two dogs were treated in this manner. The experiment was not carried further, because there was no evidence in microscopic sections of any remaining material after eight weeks. In these sections it appeared that the ordinary gelfoam was entirely replaced in both dogs before six weeks. The 8581–5 was replaced after eight weeks. Gelfoam was invaded by granulation tissue, and then was destroyed and replaced by fibrous connective tissue, the process being the same with both materials. The extent of the reaction in soft tissue was not great. In fact, we could not have found the location of the material when the animals were operated upon the second time had its location not been marked at the time of insertion by a silk suture.

With these two materials we then set out to answer the following questions if possible: (1) Could this absorbable porous mass be used as a supporting structure for bone repair with or without calcium salts and (2) Would it retard bone repair?

The experiment was divided into two different types of procedures.

In the first group six dogs were used. A cortical defect, approximately one by two centimeters in size, was created in each tibia at about the middle of the shaft. In two animals the cortical tibial defect was filled with the commercial gelfoam on one side and the experimental product 8581–5 on the other. In two other animals the defect was filled with these materials in the same way, but the material was first saturated with a suspension of tricalcium phosphate. The remaining two animals of approximately the same age and size were used as controls; a defect of approximately the same size was created in each tibia, but nothing was placed in the defect. These animals were sacrificed at

† The Upjohn Company was kind enough to provide us with a substance of the same character but which they felt would be much more slowly absorbed. This experimental material was labeled Upjohn 8581–5.

intervals, the longest being thirty-eight weeks. At autopsy the bone was sectioned above and below the defect, was fixed with 10 per cent. formalin, decalcified in nitric acid, sectioned, and stained. We found that the process of decalcification destroyed any gelfoam which may have still been present and none was ever distinguishable in any of the bone sections.

From a study of the roentgenograms (Fig. 1-A through Fig. 1-E), gross specimens and microscopic sections, we were unable to distinguish any appreciable difference in the progress of the healing of the defects filled with gelfoam, those filled with gelfoam combined with calcium, or the controls.

This would indicate that gelfoam, both the ordinary commercial type and the experimental type either with or without calcium salts, has very little effect upon the healing of a bone defect. This observation agrees with the statement of Stinchfield that gelfoam does not interfere with bone healing.

A similar set of experiments was then done in a series of seven dogs. In four animals, a section, 1.5 centimeters long, was removed from the shaft of each radius. This gap was obliterated on one side with gelfoam, the opposite side being left as a control. In three other dogs, a similar gap was created in each tibia. In two of these dogs, gelfoam saturated with a solution of tricalcium phosphate was used, and in the remaining dog gelfoam without salts was used to obliterate the gap. In an effort to prevent fracture of the ulnae and fibulae, plaster casts were applied. These casts were not effective because the dogs rapidly destroyed them. In one dog both ulnae fractured, allowing the radii to become approximated; the gaps were completely healed in six weeks. On microscopic study of these specimens, there was perhaps a little more cartilage on the side on which the gelfoam had been used. In the remaining dogs, fracture of the companion bone did not occur, and all of these failed to unite on the control as well as on the gelfoam-tested side. These animals were sacrificed at intervals of from four to twenty-four weeks. X-ray, gross, and microscopic studies (Figs. 2-A and 2-B) revealed non-union in each case, with connective tissue and cartilage between the fragments. There was perhaps a little more cartilage on the gelfoam-treated side.

From these experiments it appeared that commercial gelfoam and the experimental material 8581-5 with or without calcium salts, when used to fill defects in bone, do not retard or stimulate to any appreciable degree bone formation or repair.

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INTRA-ARTICULAR HYDROCORTISONE IN ARTHRITIS AND ALLIED CONDITIONS

A Summary of Two Years' Clinical Experience*†

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When the discovery of the effects of cortisone and ACTH on rheumatic diseases was announced in 1949 by Hench, new vistas were opened in the medical management of arthritis and allied conditions, but also new responsibilities became apparent, since the systemic administration of such hormones carried with it many new problems, limitations, and even potential dangers of which you are all aware.

Since we had the audacity, as internists, to aspirate many joints over a period of some years in an effort to learn more of the physiology and dynamic pathology of joint disease, it was only natural that we should assay the effects of cortisone as applied topically in the diseased joints themselves[2]. Great was our disappointment when we found that the effect of cortisone, so used, was quite transitory and not consistent enough to be regarded as therapeutically valuable. When others[3, 4], in brilliant experiments, showed that compound F of Kendall, now called hydrocortisone, a close chemical and physiological relative of cortisone, was the major hormone produced by the adrenal gland upon stimulation with ACTH, the idea that the tissues might respond more readily to the direct application of hydrocortisone suggested itself to us. Two years ago our first experiments with injection of hydrocortisone directly into the joints were carried out, and the results proved that hydrocortisone was vastly superior to cortisone in anti-inflammatory effect at the tissue level[5]. To our great surprise, the ameliorating effect of a single injection of twenty-five milligrams of the hydrocortisone acetate suspension into a rheumatoid arthritic joint often persisted for several weeks, and the small amount needed to produce this local benefit gave no evidence of systemic effect in diabetic, hypertensive, or psychotic patients or in patients with cardiac decompensation. Many of these patients had been used in this study because they could not partake of the relief afforded by systemic cortisone administration. Thus, some of the therapeutic possibilities of this method of hormone administration became apparent very early in our experiments. The generous supplies of hydrocortisone**, together with a simplified technique for joint aspiration and injection and an ample supply of clinical material which included joint diseases of many types, have made possible the almost incredible series of 7,352 injections into the joints, bursae, or tendon sheaths of 723 patients in the Arthritis Section of the Hospital of the University of Pennsylvania during the past two years.

TECHNIQUE

In our previous studies of joint temperature by insertion of a thermocouple directly into the joint space, we had worked out a simplified technique for aspiration of several joints. This simplified technique was also necessary for hydrocortisone injections, since we often injected as many as forty joints in a single clinic session. A brief summary of this technique is given herewith.

Ordinary office or clinic aseptic precautions, without drapes or gloves, have been used throughout. The skin overlying the site of aspiration is cleansed with a skin anti-

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** The hydrocortisone for this study was furnished by Merck & Co., Inc.

septic and alcohol. Local anaesthesia is seldom necessary, once the operator has become familiar with the technique for each specific joint. A 20-gauge aspirating needle is usually sufficient. The needle tip is freely movable when the joint space is entered. Any excess fluid is usually aspirated, both for analysis and to relieve pressure. Injection of the hydrocortisone suspension meets almost no resistance if the needle tip is free in the synovial space. After withdrawal of the needle, a small patch dressing is placed over the puncture site, and the patient resumes his normal activity.

Our technique for injecting specific joints was, in many instances, independently arrived at; a brief review follows.

The *knee*, being the easiest to aspirate and to inject, and involvement of which is the most frequently disabling of the joints affected by arthritis, has thus been the one injected most often. A tightly distended knee can be aspirated from almost any angle, but it is often difficult to aspirate the painful joint with little effusion by the usual approach. We have found that aspiration of the extended knee from the medial side opposite the mid-point of the patella, the needle being aimed to slide between the patella and the patellar groove of the femur, is consistently easy and effective. The bony ridge of the patellar groove is less prominent medially. When there is ankylosis of the patella or marked flexion deformity of the knee, we have inserted the needle beside the patellar tendon, through the fat pad, into the joint space between the condyles. Baker's cysts, unless readily communicating with the joint space, are injected directly from a posterior approach. The usual dose for the knee is 25 or 37.5 milligrams of the hormone suspension.

For the *ankle*, we have tried several approaches, but find the most consistently successful one is from the anteromedial aspect, just medial to the extensor hallucis longus tendon, and about one centimeter above the level of the tip of the medial malleolus. The needle must penetrate about three centimeters at this point to reach the synovial cavity. Aspiration of up to ten cubic centimeters of fluid is often easy. About twenty-five milligrams of hydrocortisone is the usual dose.

For the smaller joints of the ankle and foot, it is essential that the operator have a roentgenogram before him; fluoroscopic guidance may also be employed. We usually use a one-inch, 22-gauge needle and a dorsal approach. Often the needle must be teased down between the bony margins and aspiration of fluid is seldom possible. If the needle has penetrated deep enough without undue force and feels free, and if only gentle pressure on the plunger is needed for injection, one may be confident that the synovial space has been penetrated. Five to ten milligrams of hydrocortisone is usually effective.

We find the *hip* the most difficult joint to inject with certainty. Our failures in hip-joint injections are nearly 50 per cent., probably because of faulty penetration. We have not found fluoroscopic guidance helpful here, as good visualization is almost impossible except in very thin patients in whom the injection is relatively easy even without it. With the hip in maximal extension and external rotation, the needle is inserted at a point several centimeters below the anterior superior spine, and about three centimeters lateral to the femoral artery as determined by its pulsation. The angle is determined by careful observation of the roentgenogram and the needle must penetrate as much as five to six centimeters in obese patients before going through the ligaments into the thin synovial space. Aspiration of fluid is usually more successful if the needle is aimed at the lower portion of the femoral head. Our usual dose of hydrocortisone for the hip is 1.5 cubic centimeters (or 37.5 milligrams). The lateral approach to the hip has not yet been successful.

In the *shoulder* the easiest and most successful approach is the anterior, just below the coracoid process of the scapula, and just medial to the humeral head. The depth of penetration to the anterior lip of the glenoid fossa may be as much as three to four centimeters in muscular patients. A dose of twenty-five milligrams (one cubic centimeter) is usually sufficient. If the subdeltoid bursa is inflamed, the injection is made directly into it.

TABLE I

RESULTS FROM HYDROCORTISONE INJECTIONS FOR RHEUMATOID ARTHRITIS *

Site	No. of Injections	Failures	
		No.	Per cent.
Knee	1,758	43	2.4
Ankle or tarsal joint	149	21	14.1
Wrist	119	38	32.0
Phalangeal joint	74	3	4.1
Elbow	91	2	2.2
Hip	52	12	23.1
Shoulder	30	3	10.0
Temporomandibular joint	5	3	60.0
Sternoclavicular or acromioclavicular joint	5	1	20.0
Olecranon bursa	36	5	14.4
Bunion	6	2	33.3
Total	2,325	133	5.7

* The results given in this table are those compiled to June 1952. The results as of January 1953 would be approximately twice the numbers given here.

The acromioclavicular joint is easily penetrated from a superior approach and the sternoclavicular joint from an anteromedial approach with a small needle. These joints seldom require more than ten to fifteen milligrams of hydrocortisone to suppress inflammation.

The *elbow* may be easily aspirated and injected from either of two approaches. It may be held either in maximal extension, to distend the capsule tightly, or at 90 degrees. In a distended joint the needle may be inserted lateral to the olecranon process, and penetration is made parallel with the ulna just distal to the lateral epicondyle.

When there is little effusion, or when the injection is being given for "tennis elbow", the lateral approach has been preferable. For this the elbow is held at 90 degrees and a one-inch 22-gauge needle is inserted at the point of maximal tenderness to a depth of about 0.5 centimeter between the head of the radius and the articulating surface of the epicondyle. About twenty milligrams of hydrocortisone is usually sufficient.

In the *wrist* several approaches are possible, but the dorsal insertion just distal to the radius has been the most successful in our experience. Occasionally fluoroscopic guidance may be found necessary. Fifteen to twenty-five milligrams of hydrocortisone is usually the effective dose. The multangulometacarpal joint of the thumb, so often painful in osteo-arthritis, is relatively easy to penetrate with a small needle from a lateral, dorsal, or even palmar approach. The metacarpophalangeal and interphalangeal joints have been easily punctured and injected dorsally from either the medial or the lateral side. Finger joints require no more than five milligrams of hydrocortisone.

For the *temporomandibular joint* affected by rheumatoid arthritis or osteo-arthritis or painful from "clicking jaw" we have also been able to give relief by the intra-articular injection of ten to fifteen milligrams of hydrocortisone. The injection is given from the lateral approach with a 24-gauge needle inserted just below the zygomatic arch, one centimeter anterior to the tragus of the ear.

At times we have injected small amounts of hydrocortisone into the sternomanubrial region and into costochondral junctures which were tender from previous trauma. We have also injected trochanteric bursae, bunion sacs, olecranon bursae, prepatellar bursae, and the flexor-tendon sheaths of the fingers with success, but the techniques for these have been largely on a hit-or-miss basis.

Injections into joints or other synovial spaces may be repeated as often as necessary. We have re-injected a single joint for rheumatoid arthritis as many as thirty-eight times at intervals of from one to four weeks with consistent benefit. In many of the local or

TABLE II

RESULTS FROM HYDROCORTISONE INJECTIONS
(As of June 1952)

Site	Osteo-arthritis		Miscellaneous (Gout, Traumatic Lesions, and Others)	
	No. of Injections	Failures (*Per cent.*)	No. of Injections	Failures (*Per cent.*)
Knee	1,034	10	55	4
Ankle	7	28	13	0
Wrist	6	17	16	0
Phalangeal	54	17	8	0
Elbow	18	6	25 (tennis elbow)	12
Hip	77	53	0	0
Shoulder	4	50	11 (reflex dystrophy)	82
Sternoclavicular or acromioclavicular joint	2	50	0	0
Subdeltoid bursa				
Acute			24	17
Chronic			49	52
Olecranon bursa			3	0
Prepatellar bursa	2	0	1	0
Bunion			4	25
Tendon sheaths	7	28	15	20
Total	1,211	13	224	22

self-limited conditions a single injection has given relief from pain and swelling which has persisted to the present. The injection must be made directly into the inflamed sac to produce benefit, but no harm results from misplacement of the suspension into nearby tissues.

The dosages mentioned above are empirical. The effect is not purely quantitative, since larger doses are not often more beneficial, and the larger amount of injected material may increase the incidence of temporary exacerbation of symptoms after injection. The mode of action is unknown, but we have determined that the material is rapidly taken up and held in the synovial cells.

Whenever the injections were given for rheumatoid arthritis or other systemic disease, they were used as an adjunct to approved systemic therapy. In localized conditions, as in bursitis, tennis elbow, and tenosynovitis, they were used alone. In order to avoid systemic effects from the hydrocortisone, no more than two joints were injected at any one visit. Thus, as often happened, a patient with four involved joints received injections in two joints each week.

RESULTS

We have arbitrarily divided the results into successful injections and failures, although all possible gradations from complete amelioration to no effect, or even occasional temporary worsening, have been noted. A *successful injection* was one which produced *unequivocal improvement in symptoms and signs which lasted a minimum of three days.* Anything less, even though marked relief was noted for two days, was counted as a failure, since the relief did not persist long enough to be of practical therapeutic value.

ANALYSIS OF RESULTS OF INDIVIDUAL INJECTIONS

Although we have now performed 7,352 injections of hydrocortisone into synovial spaces, we have not completely analyzed our results to date. In June 1952, when our last complete analysis of individual injections was compiled, we had performed 3,757, or only

TABLE III

SUMMARY OF FOLLOW-UP ON 547 PATIENTS OBSERVED FOR SIX MONTHS OR LONGER AFTER LOCAL INJECTIONS OF HYDROCORTISONE

	No.	Per cent.
One or more local injections successful so that no further treatment was required	106	19.4
Repeated injections at variable intervals still productive of continued benefit (mostly for rheumatoid arthritis and osteo-arthritis)	296	54.1
Local injections successful, but patients lost to follow-up; seven patients died from systemic disease	65	11.9
Benefit inadequate from injections, or total failure after repeated trials	80	14.6

about half the present number. Since sampling of case records shows about the same distribution and results, we have assumed that doubling the old figures will give the approximate results to date. Table I shows the results of individual injections into the joints in 249 cases of rheumatoid arthritis. Almost 80 per cent. of the injections were into the knee. The over-all per cent. of failures was only 6 per cent., but in some joints the incidence of failures was much greater. The average degree of amelioration of signs was approximately 60 per cent. and the average duration of relief from each injection was approximately eight days, but in some instances complete relief was noted for many weeks.

In Table II are recorded the injection results in other forms of rheumatic disease. In 231 cases of osteo-arthritis, the over-all results were good, with only 13 per cent. of failures, but a low incidence of failures in the 1,034 knees compensates for the less encouraging results in other joints, such as hips with malum coxae senilis in which 53 per cent. of failures were encountered. Even 50 per cent. of success in temporary palliation of this condition could be considered encouraging, however. The average duration of relief in osteo-arthritis was about two weeks, and relief whenever it occurred was almost complete. There were fourteen patients with osteo-arthritic knees who have had almost complete relief for eighteen months or more without re-injection. Many of the failures in osteo-arthritis may be attributed to the difficulty of aspiration, since effusion was uncommon.

In gout the results from injection were extremely good. In the acute forms of traumatic arthritis the results were also excellent and frequently persisted indefinitely, if support to the part was also used. Tennis elbow responded promptly to one or two injections, usually with persisting relief.

Traumatic tenosynovitis, a category in which we included peritendonitis crepitans, snapping thumb, trigger finger, and DeQuervain's stenosing tenosynovitis, also responded well. Our usual result in acute subdeltoid bursitis was a prompt, complete relief often occurring within a few hours, and nearly always with lasting remission of all symptoms. Chronic subdeltoid bursitis did not respond so well, however, about half of the injections being unsuccessful.

Injection of the shoulder joint for so-called reflex sympathetic dystrophy, or the shoulder-hand syndrome, was seldom successful in our hands. Painful bunions may be palliated by this procedure, but, as in all conditions, the underlying deformity must still be corrected by orthopaedic measures.

During the past few months we have seemingly loosened the fibrous contractures of the palm in three cases of early Dupuytren's contracture by repeated infiltration of the palmar fascia with a 50 per cent. mixture of hydrocortisone and procaine. It is too early to draw conclusions, however.

In one case of parahemophilia from accelerator globulin deficiency it was possible to palliate the pain and prevent post-hemarthrotic adhesions by aspiration and intra-

TABLE IV

INCIDENCE OF ADVERSE REACTIONS IN 7,352 HYDROCORTISONE INJECTIONS
(To January 1953)

Type	Number	Incidence (*Per cent.*)
Local exacerbation (2–72 hours)	142	1.9
Local weakness (4–96 hours)	15	0.2
General weakness, malaise, vertigo (12–96 hours)	10	0.13
Urticaria locally after injection	4	0.05
Infection of knee from injection (with thrombophlebitis of leg)	1	0.015
Aggravation of tuberculous arthritis (following initial palliation)	1	0.015
Total	173	2.3

articular injection of hydrocortisone. Likewise, the acute joint manifestations of lupus erythematosus and periarteritis have been suppressed by such injections. As in any disease of systemic origin, this local therapy can only be an adjunct to general therapy, but it illustrates the non-specific alleviating effect of the hormone.

FINAL RESULTS

Good results from individual injections are not necessarily synonymous with a successful outcome. Some of our patients with early success from hydrocortisone injections later failed to respond, whereas others responded poorly to early injections and much better to repeated injections. Of the 547 patients followed six months or more, most of the 106 achieving a lasting amelioration for longer than six months had a localized or self-limited condition. Most of the 296 patients still on maintenance therapy by repeated injections have chronic arthritis. We do not claim any cures, but have often seen indefinitely persisting palliation of localized or self-limited conditions. In the third group (12 per cent. of the series) are patients in whom the injections were apparently locally beneficial, but who failed to return or to notify us of results. Also included are seven patients who died during the period of study. The cause of death in none was attributable to the injections, as determined either by time interval or by the type of lesion found at autopsy. In eighty cases (14 per cent.) therapeutic failure was encountered.

ADVERSE REACTIONS TO LOCAL INJECTIONS OF HYDROCORTISONE

A total of 173 untoward responses followed local administration of hydrocortisone. This constitutes but 2.3 per cent. of the total of 7,352 separate injections. As can be seen in Table IV, the great majority of these occurred in the form of a temporary local exacerbation of the joint inflammation. This appeared within a few hours following injection in most patients, but was delayed nearly twenty-four hours in a few. The duration of this superimposed acute arthritis varied from two to about seventy-two hours. Although in some instances this was alarming and extremely painful, it was temporarily incapacitating in only a few. It should be noted that this reaction, even in its more severe form, did not discourage most of these patients from returning promptly for further injections. In no instance did such exacerbations last longer than seventy-two hours and, more often than not, subsequent improvement over the pre-injection state was noted, occurring some twenty-four to forty-eight hours after the reaction had disappeared. Joint-fluid cultures and other studies designed to determine the cause of these reactions have not been revealing. The use of codeine, ice packs, immobilization of the involved joint, and aspiration of tense effusions, when present, effectively controlled the more severe reactions. We have not considered such reactions to be contra-indications to further local therapy at the same site or at others, and only six of our patients have experienced more than one of these episodes despite repeated subsequent injections.

A bizarre transient weakness after injection was described by fifteen patients,

occurring in the extremity of the injected joint. This was never disabling and usually disappeared within a few hours. Even the most protracted of these reactions did not exceed three or four days, and in no instance were we able to find evidence to support an organic origin for this complaint. Ten patients experienced a generalized weakness, associated with malaise and "light-headedness". This followed a similar non-incapacitating and transient course, and its possible organic origin was again obscure. These two types of undesirable responses are unexplained and warrant further observations, but have not, to date, been of clinical importance because of their rarity and their benign characteristics.

Hypersensitivity was observed in only four patients and was manifested by local urticaria in all instances. Procaine hydrochloride in a 1 per cent. solution given concomitantly to obtain anaesthesia at the site of local therapy, was found responsible for the allergic reaction in three of these patients; the fourth was found by skin test to be hypersensitive to suspending agents in the aqueous vehicle of the hydrocortisone suspension.

Although over 7,000 injections were made into locally diseased tissues, in only one was infection introduced into the site under study. An acute staphylococcic arthritis was superimposed on the rheumatoid arthritis in the knee of this patient. The patient was on a systemic cortisone regimen and had a mild acne involving the skin through which the needle was introduced. The joint infection was quickly controlled with an antibiotic. A concomitant thrombophlebitis was controlled by anti-coagulants. Obviously, better judgment in selection of the injection site would have avoided this one experience. It is noteworthy that this was the only joint infection produced, even though only the routine aseptic precautions of office or clinic practice were used.

A case of tuberculous arthritis of an ankle was included in this series through misdiagnosis. When relapse followed the initial period of palliation, the patient was transferred to the Orthopaedic Department and proper therapy was instituted.

DISCUSSION

Once more, it should be emphasized that the usual general therapy for these rheumatic conditions, wherever indicated, was begun before or concurrently with the start of local hydrocortisone injections. Without doubt, general treatment was, in many instances, contributing to the improvement observed in the course of the disease.

It was our intention to select a large number of patients suffering from various types of rheumatic disease for local treatment with this drug. The spontaneous variations and the psychogenic improvement in rheumatic diseases produced by any treatment, especially one in which a new medicine is instilled directly into the site of discomfort, presupposes major improvement in a few patients, and minor, indefinite improvement in many. It was felt that the promptness of response in the large number of patients treated, the variety of disorders studied, and the relatively long study period should make our statistics significant; the indications and contra-indications could be more clearly delineated; and untoward reactions would be more likely to occur in the frequency which they would probably attain should this therapeutic measure gain wide-spread acceptance.

Although two years is certainly insufficient to observe long-term effects of any form of therapy, we feel that this clinical therapeutic study has accomplished at least some of the above objectives. We conclude that local therapy with hydrocortisone is indicated:

1. For acute or chronic inflammation of one joint or at most a few peripheral joints. Inflammation secondary to infection is, of course, excluded.

2. For acute or chronic non-specific inflammation of bursae and tendon sheaths.

3. For one or a few painfully disabling joints, even in the presence of widespread joint disease.

4. For the suppression of local disease in a few of the more actively involved joints, while "specific" systemic therapy (such as gold, cortisone, or others) effects its more slowly evolved benefit, or in cases in which specific systemic therapy is contra-indicated.

5. For suppression of inflammmation in the more resistant joints, allowing maintenance on systemic cortisone therapy either more effectively,or at a lower total dosage level.

6. For suppression of inflammation in joints showing early and actively progressive deformity, in order to expedite the effect of physical therapy, traction, casts, splints, or other corrective measures.

7. For suppression of joint inflammation in preparation for or following orthopaedic surgery.

The following were found to be contra-indications to the use of hydrocortisone locally:

1. The presence of proved or suspected infection in or near the joint. Local instillation of hydrocortisone into or through such diseased tissues may aggravate the spread of the infection.

2. Proved or suspected hypersensitivity to either hydrocortisone or the constituents of the suspending vehicle. This occurs in rare cases.

Our experience shows that little if any benefit is to be expected and that certain dangers may be inherent in the local administration of hydrocortisone in the following circumstances:

1. Diseased spinal joints. These do not lend themselves to this type of therapy either because of anatomical inaccessibility or because of multiplicity of involvement.

2. Joints devoid of synovial space. Such joints do not usually respond.

3. Active inflammation in multiple joints. Intra-articular therapy is futile unless only one or a few joints become particular problems.

4. Therapeutic failure on repeated trials. If three successive injections fail to produce definite improvement, further injections are seldom beneficial.

5. Severe trauma with joint derangement, particularly with fracture of the bones or cartilage. Repeated instillation of hydrocortisone may be contra-indicated because of the theoretical hazard of inhibiting normal healing.

6. When the diagnosis has not been established. Complete diagnostic case study must precede intra-articular hydrocortisone therapy. Comprehensive therapy, including orthopaedic and physiotherapeutic measures, must first be applied wherever indicated.

Further and more extensive reports on the use of intra-articular hydrocortisone as an adjunct to orthopaedic procedures are needed. Since the adverse reactions among 7,352 injections were few in number, and nearly always mild and self-limited, there need be no fear in attempting such therapy.

After two years of extensive clinical trial of local therapy by intrasynovial injection of hydrocortisone, we conclude that this is often a temporary, but usually an effective, palliative treatment in most localized rheumatic conditions.

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EXPERIMENTAL TENDON REPAIR WITHIN THE FLEXOR TUNNELS

The Use of Hydrocortisone without Improvement of Function in the Dog *

BY RICHARD I. GONZALEZ, M.D., SAN FRANCISCO, CALIFORNIA

From the Laboratory for Surgical Research, Stanford University School of Medicine, San Francisco

The inability to achieve consistently good functional results after primary tendon repair within the flexor tunnels is still a major problem of tendon surgery. Fortunately it is possible to reproduce the problem experimentally and to investigate possible solutions under controlled conditions. The anatomy of the flexor mechanism in the dog is almost the exact counterpart of that in man. In the dog there are two flexor tendons enclosed in a tight fibrous tunnel in the region of the metacarpophalangeal joint. The flexor tendons of the index and little toes are distinct and widely separated. They are each enclosed in a separate tendon sheath. Experimentally one can measure the effect of various drugs or techniques following primary tendon repair in this difficult area. The flexor tendon of the index toe and that of the little toe in the same paw can be repaired simultaneously. That of the index toe serves as an experimental tendon and that of the little toe as a control.

On the basis of this experimental situation the local effect of hydrocortisone upon tendons repaired within the flexor tunnels was investigated. From this study the author hoped to be able to answer three questions:

1. Does hydrocortisone improve tendon function following primary repair within the flexor tunnels?
2. Does hydrocortisone interfere with tendon healing?
3. What is the fate of hydrocortisone in the tissue?

HISTORY AND STRUCTURE OF HYDROCORTISONE

The isolation of hydrocortisone from the adrenal cortex and the formulation of its chemical structure were achieved by Kendall and his associates in the early part of 1938. Chemically this compound, described by these authors as compound F, is a close relative of cortisone, an OH group being substituted for the O at carbon position 11, the chemical name for the compound being 17-hydroxycorticosterone. Polley and Mason first used the drug clinically in 1950. They used it systemically and noted clinical results comparable to those following the systemic use of cortisone. According to Hollander and his co-workers, Thorn used the drug intra-articularly in one case in 1950; however, extensive local use of the drug was not made until 1951, when Hollander and his associates, in a large series of patients, investigated the drug. The almost miraculous increase in the mobility of stiffened joints following the intra-articular use of small amounts of hydrocortisone, together with the production of marked changes in fibrous structures about or within these joints, led the author to hope that the drug might prevent excessive fibrous-tissue formation about healing tendons and therefore improve the function of tendons repaired within the flexor tunnels.

EXPERIMENTAL METHOD

The details of this method have appeared elsewhere [1], but may be summarized as follows: Mongrel dogs of either sex were anaesthetized and the volar area of their forepaws was shaved and scrubbed with aqueous zepherin solution. The common flexor tendon mass in the wrist was mobilized through a mid-line wrist incision and a tension pull-out wire was

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 23, 1953.

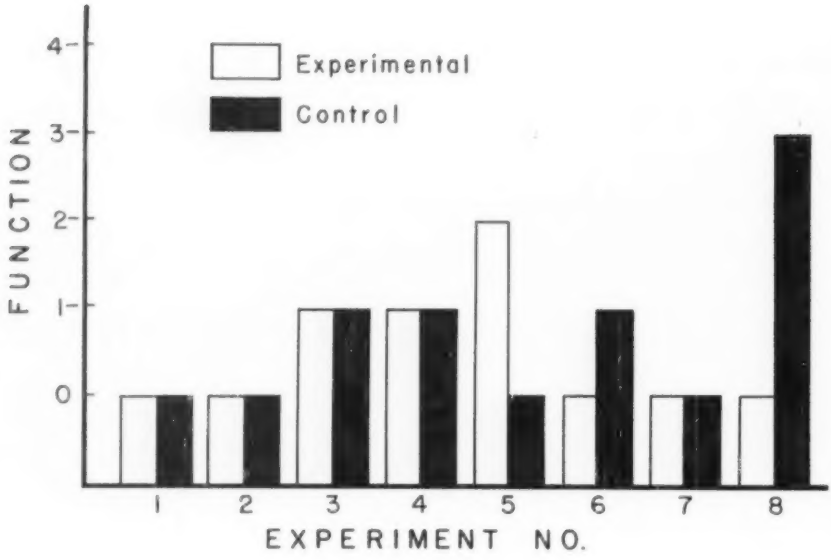

CHART I

placed through the mass, so that the tendons were relaxed distally. The flexor tendons were then exposed within the flexor tunnel of the index toe, the pulley was slit, the sublimis was excised, and the profundus was transected and repaired with a single right-angle suture of No. 36 stainless-steel wire. Finally the area was flooded with 0.25 cubic centimeter of hydrocortisone (twenty-five milligrams per cubic centimeter). The tendon of the little toe was then cut and repaired in exactly the same manner, but without instillation of the drug. The wrist was held in a position of volar flexion for three weeks by means of a padded, re-enforced cast. At the end of twenty-one days * the tendons were re-exposed, their function was graded †, and the tendons were exposed and removed. Their tensile strength was measured by a tensiometer. Of an original series of thirteen dogs only eight are included in this report, since in the remaining dogs both experimental and control tendons failed to heal for technical reasons such as inadequate immobilization due to premature destruction of casts or premature breaking of the tension wire. There were no instances of infection or of death.

RESULTS

Effect of Hydrocortisone upon Function

The functional results of the tendons bathed in hydrocortisone were no better than those repaired without benefit of the drug (Chart I).

Grossly there was no apparent difference in number or density of adhesions about the anastomotic site of the control tendons and experimental tendons.

* In the three hundred odd experimental tendon repairs done on dogs by the author, the tendons invariably healed strongly in three weeks, if the procedure had been well done technically and if the tendons had been kept relaxed.

† Function was graded by measuring the excursion of the distal portion of the tendon when traction was applied to the proximal palmar portion of the tendon and by noting the amount of force required to pull the tendon free after it had been transected at its insertion. A normal tendon has a distal excursion of three to eight millimeters and, after the insertion has been cut, it pulls free with a minimum of traction. An experimental tendon which behaved in this manner was graded + + + +. A tendon which had two to three millimeters of distal excursion but could not be pulled free was graded + +. A tendon which barely moved was graded +. A tendon which had no distal motion or had not healed was graded 0.

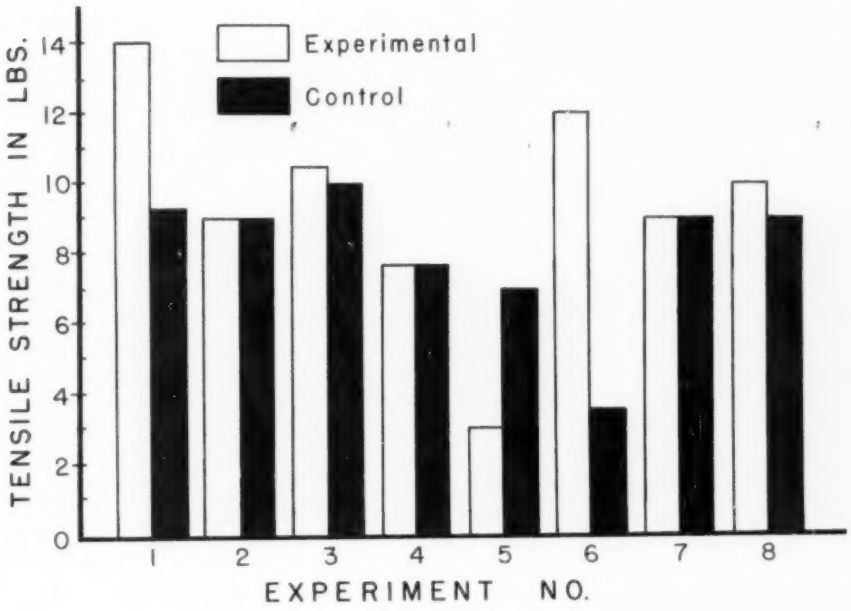

CHART II

Effect of Hydrocortisone upon Healing

The tendons bathed in hydrocortisone exhibited essentially the same tensile strength at three weeks as did the controls (Chart II).

Fate of Hydrocortisone in the Tissues

In three out of eight dogs remnants of the drug were found in the tissue. These appeared as a mass of soft, white, caseous material. In one instance the mass was quite large, measuring three to four millimeters in its greatest diameter. There was no gross reaction about these drug masses. In a few of the dogs it was noted that the experimental side appeared to be more vascular and "boggy" than the control side. However, this was not a constant finding.

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DISCUSSION

Preceding the presentation by Dr. Gonzalez and Dr. Howard, Dr. Bunnell, and Dr. Pratt, Dr. Grant presented a paper on The Effect of Cortisone on Healing of Tendons in Rabbits. For an abstract of that paper, see Proceedings of the American Society for Surgery of the Hand in the April issue of *The Journal* (35-A: 325, 1953).

DR. ELDEN C. WECKESSER, CLEVELAND, OHIO: I should like to describe briefly some work we have done in the last two years with the use of cortisone in the prevention of adhesions. Our results were much the same

(*Continued on page 1002*)

THE USE OF COMPOUND F (HYDROCORTONE) IN OPERATIVE AND NON-OPERATIVE CONDITIONS OF THE HAND*

BY LOT D. HOWARD, JR., M.D., DONALD ROY PRATT, M.D., AND STERLING BUNNELL, M.D., SAN FRANCISCO, CALIFORNIA

Compound F, also known as substance M, hydrocortisone, hydrocortisone acetate, hydrocortone, and chemically identified as 17-hydroxycorticosterone-21-acetate, is a synthesized adrenal cortical hormone. Its chemical formula differs from that of compound E (cortisone) only in the substitution of the hydroxy radical (OH) for the oxygen (O) radical, as shown in Figure 1.

The isolation of the adrenal cortical hormones is a landmark in the progress of medical research. The outstanding contributions of such men as Hench, Kendall, Wintersteiner, and Pfifner in this country and of Reichstein of Switzerland resulted in the isolation of some twenty-eight crystalline compounds from the adrenal cortex, of which four

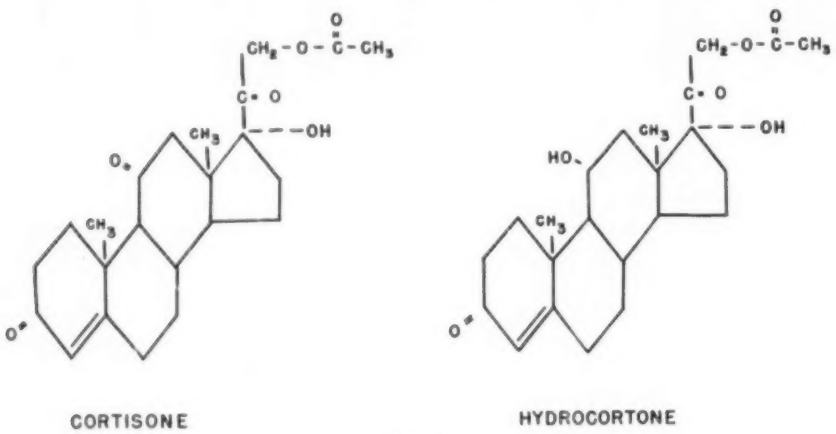

FIG. 1

Comparison of the chemical formula of cortisone and hydrocortone.

showed pronounced physiological activity. Of the four, compound E (cortisone) and compound F (hydrocortone) have proved to be of most value. Compound F was synthesized in 1950 and became available in January 1951.†

Compound F has the same physiological properties as cortisone but is believed to be approximately 50 per cent. more potent. Its principal advantage over cortisone lies in the fact that, when injected in small amounts intra-articularly, it produces local relief at the tissue level without generalized systemic effects.

Basically, the action of compound F is presumed to be the same as that of cortisone, although the precise mechanism has not been fully described. The action of cortisone, on the basis of present knowledge concerning the structure and physiology of connective tissue, although complicated and not completely understood, can be outlined as follows:

Connective tissue consists of cellular elements, or fibroblasts, and non-cellular elements such as ground substance, fibers, and basement membrane. The non-cellular

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 23, 1953.

† At the present time compound F is obtainable as a crystalline suspension in saline solution containing twenty-five milligrams per cubic centimeter and is marketed in sterile vials five cubic centimeters in size for intra-articular injection.

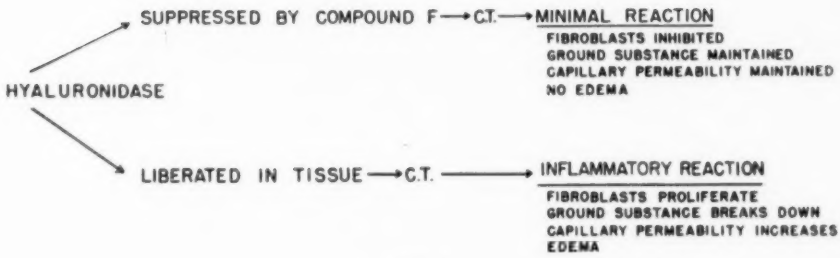

FIG. 2

Diagram showing how compound F acts in its role with hyaluronidase and the connective-tissue system (*C. T.*).

elements and particularly the ground substance, which is a hydrated gel, are composed principally of mucopolysaccharides, of which hyaluronic acid is the most abundant.

The production and maintenance of connective tissue depends on the activity of fibroblasts and the regulating principles governing the physiology of tissue. Such regulators are enzymes, vitamins, and hormones. Of the enzymes, hyaluronidase is notable in that it acts to increase capillary permeability, to stimulate fibroblastic activity, and to depolymerize hyaluronic acid with the liberation of water-soluble aggregates. The activity of this enzyme therefore amounts to an inflammatory reaction with oedema and cicatrization. Hyaluronidase is believed to be liberated by damaged tissue through either allergic or non-allergic inflammatory processes or trauma.

Hyaluronidase is held in check by anti-hyaluronidase factors of which the adrenal cortical hormone cortisone is the most important (Fig. 2).

From the preceding it can readily be seen that a drug, such as compound F, acting locally at the tissue level and inhibiting inflammatory reaction from whatever cause should be the ideal supplement for both operative and non-operative conditions of the hand [6, 12, 14, 19].

The literature on compound F for other than intra-articular injection is scanty, mainly because of the fact that the drug is designated for that use only. However, Orbach treated eight patients with acute and chronic bursitis with injections of one cubic centimeter of compound F and was so impressed with the results that he ventured to predict all other methods of treatment would "probably" become obsolete. Uniformly good results are reported by numerous workers [2, 11, 17, 20] who used compound F intra-articularly in both rheumatoid and osteo-arthritic joints. No complications were encountered and repeated injections seemed to be as effective as the first one. Clinical improvement, both symptomatic and on examination, lasted from one to three or more weeks following each injection.

After observing dramatic improvement in a case of rheumatoid tenosynovitis following a single injection of 0.2 cubic centimeter of compound F, we became aware of the possibility of a broader application of the drug in hand conditions. Therefore, some seventy patients with hand conditions, both with and without operation, have been treated in an effort to determine in what type of case compound F would prove of value. The dosage of the drug was empirical, varying from 0.1 to 0.5 cubic centimeter in most instances. In the patients not operated upon, the drug was injected at the site of the lesion. In those who were operated upon, injection was made into the space of the operative wound following closure. In some instances the drug was used but once, in others it was repeated.

In this series, compound F has been used for only seven months and most of the patients came under treatment during the last three months of that period. The follow-up, therefore, is short and inconclusive from the standpoint of long-term evaluation. How-

ever, the preliminary results were so impressive to the authors in some instances that a report seemed warranted.

To the present time the results have been judged purely on clinical impression, patients who have had injections being compared to similar cases without treatment during past experiences.

Distribution of Cases	*No.*
Tenosynovitis	11
Trigger finger	12
de Quervain tenosynovitis	3
Hard dorsal oedema of hand	2
Ganglion	5
Rheumatoid arthritis	2
Osteo-arthritis	3
Dupuytren's contracture (postoperative)	9
Tendon freeing	6
Tendon suture	4
Postoperative reconstruction	9
Miscellaneous	4
Total	70

Tenosynovitis

Of eleven patients with tenosynovitis, ten were improved, one was unimproved, and there were no complications.

Extensors	6
Flexors	3
Both flexors and extensors	2
Treatment without operation to date	8
Treatment before and after operation	1
Treatment at time of operation	2

Of the eleven cases, one seemed definitely traumatic in origin. The other ten were gradual in onset and occurred predominantly in females, the ratio being seven to three, and probably were rheumatoid in origin.

The response in general to treatment was the same regardless of location of the involvement. In twelve to twenty-four hours the pain ceased and swelling subsided. Of the eight patients treated without operation to date five received but a single injection and three have received two or more injections. The two patients treated at the time of operation had a smooth, pain-free postoperative course. The one patient who was unimproved had localized tenderness along the extensor carpi ulnaris tendon.

The patient treated before and after operation had tenosynovitis of the finger extensors which was kept under control from May 1952 until her operation in January 1953. To accomplish this, 0.2 cubic centimeter of compound F was injected locally about once a month.

In this group, recurrences, prolonged treatment, and even the development of tenosynovitis at other sites were to be expected. Nevertheless, for immediate treatment and relief of the complaints the use of compound F locally seems warranted. Following surgical treatment compound F seems to smooth the postoperative course.

Trigger Finger

Of twelve patients with this condition eleven were improved, one was unimproved, and there were no complications.

Trigger finger involving a single digit		10
Thumb	4	
Long finger	3	
Ring finger	3	
Trigger finger involving multiple digits		2
Treated without operation	6	
Treated before and after operation	1	
Treated postoperatively only	5	

Of the six patients treated without operation, to the present time all have been relieved of pain; the trigger symptom has gone from all but one and for this one only a mild and intermittent trigger action persists. Three patients required but a single injection, two required two injections, each about a week apart, and one required weekly injections for three weeks. The patient without improvement failed to respond after two injections.

Two surgeons are included in the group without operation. One reported relief starting four hours after the first injection of a trigger thumb. The other was relieved of his pain and the trigger symptom disappeared only to return later, but to a less severe degree.

The one patient treated both before and after operation had two trigger fingers on one hand and one on the other. The trigger symptoms had been present for two years; they had developed following bilateral release of the deep carpal ligament for tenosynovitis. Preoperative treatment relieved the trigger action and at operation very little evidence of tenosynovitis was present.

Of the five patients treated postoperatively only, all received compound F in the wound at the time of closure. All had healing *per primam* with minimal or no pain and early motion could be started and maintained almost immediately following surgery.

Previous to the use of compound F as an adjunct in the treatment of trigger finger, many patients have been operated upon with good results. However, some have had rather stormy convalescence due to rheumatic-type flare-up and it is in this type of case and in those patients refusing operation that the drug may be of considerable benefit.

de Quervain's Tenosynovitis

Of three patients all three showed improvement and there were no complications.

Treated, without operation	2
Treated before and after operation	1

Of the two patients treated without operation one had bilateral and chronic involvement which had been present over one year. The right side was more severely affected and therefore was treated first with 0.3 cubic centimeter of compound F. All pain disappeared in twenty-four hours. One week later slight soreness had recurred on the right. Both sides were then treated at the patient's request. Surgery was advised but was refused. A month later she was still symptom-free and was working.

The other case was unilateral and acute. Two weeks of conservative treatment elsewhere had been without benefit. Five-tenths of a cubic centimeter of compound F injected locally relieved all symptoms and the patient returned to work the following day. One month later he was still working and was symptom-free.

The patient treated by compound F both before and after surgery also had an acute attack, which was of three weeks' duration. Four-tenths of a cubic centimeter of compound F injected locally relieved all symptoms within twelve hours. Two days later surgical treatment was carried out and compound F was again given in the postoperative wound. The recovery was uneventful.

It is probable that the patients without operation may have recurrence and eventually need surgical correction. However, symptomatic relief can apparently be accomplished in a short time by the use of compound F.

Hard Dorsal Oedema of the Hand

Of the two patients with this condition one was improved and the other remained unimproved; there were no complications.

The patient without improvement was a male forty-five years old whose case was one of long standing. A single injection of 0.5 cubic centimeter of compound F failed to have any effect whatsoever.

The improvement occurred in a twenty-year-old male who had been under observation for sixteen months and who had recurrence after two surgical excisions. For the past several months the swelling has been kept under control by repeated injections of compound F.

The failure of response in this case of long duration may be due to the maturity of the scar, and in that way this case may be similar to Dupuytren's contracture.

Ganglion

Of five patients with this condition all five remained unimproved.

Dorsal surface of wrist	4
Volar surface of wrist	1
Patients treated without operation	4
Patients treated by operation	1

Of the patients treated without operation, three had typical dorsal wrist ganglia and were unaffected by single or multiple injections of compound F. One small symptomatic dorsal ganglion near the base of the metacarpal of the index finger responded promptly after administration of 0.3 cubic centimeter of compound F locally. The ganglion recurred two and a half weeks later but, although it reached its former size, the symptoms remained of less intensity.

The patient on whom operation was performed, a surgeon, had presented a swelling on the volar aspect of the wrist overlying the flexor carpi radialis tendon. The clinical signs were indicative of ganglion. An injection of 0.3 cubic centimeter of compound F was given and repeated in three weeks. In each instance some temporary relief of symptoms and swelling occurred. Operation was performed three days after the third injection and, although the material removed appeared clinically and microscopically like a ganglion, there was no cyst. An anomalous tendon and a degree of tenosynovitis were found about the tendon of the flexor carpi radialis and this alone could have been the cause of the disturbance.

In this limited group the simple ganglion did not respond to treatment with compound F.

Rheumatoid Arthritis

Of two patients both were improved and there were no complications. Operation was not performed in either.

In one patient both proximal and distal joints of the right thumb were involved. There was alleged injury, but x-rays were negative. Conservative treatment over several months' time was not effective. Approximately 0.1 cubic centimeter of compound F was injected into each joint and the same dose was repeated in two weeks. The result was prompt resolution of swelling and pain.

The other patient had involvement of the middle joint of the ring finger and the proximal joint of an index finger. Small single injections into each joint gave prompt relief. During the period of observation of this case, a mild tenosynovitis occurred in the area with the de Quervain type of involvement and trigger action developed in the ring finger. Both conditions responded to local injections of compound F.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Result following primary repair of flexor profundus tendons with silk in long, ring, and little fingers.

Fig. 3-B: The same hand after tendon freeing, removal of silk, and the use of compound F locally in the wounds at the time of closure.

In view of previous work and reports by other investigators, the results in the above two patients were to be expected. Neither patient can, however, be considered cured.

Osteo-Arthritis

Of three patients in this group all three were improved and there were no complications. Operation was not performed in any.

Each patient had involvement of a single joint. One case was traumatic in origin and the arthritis involved the middle joint of the little finger. The other two were local manifestations of degenerative arthritis, one involving the metacarpocarpal joint of the thumb and the other involving the distal joint of the little finger. Intra-articular injections of compound F gave complete but temporary relief in all cases.

Here again the response to the drug confirms the reports in the literature.

Dupuytren's Contracture

Of nine patients all nine were improved and there were complications in two.

Treated postoperatively		9
Complete fasciectomy	4 (1 bilateral)	
Local fasciectomy	5	

In view of previous studies on cortisone in this condition [1], no attempt was made to treat Dupuytren's contracture preoperatively with compound F. At operation in each case, approximately 0.5 to 1 cubic centimeter of compound F was injected into the wound space at the time of closure. In no instance was healing of the wound delayed. In two cases small postoperative hematomata occurred which required evacuation. These two cases represent complications of treatment but are not necessarily due to compound F, although in this small series they are so listed.

The outstanding difference between patients treated with compound F and those untreated has been the almost complete absence of postoperative pain and the minimal postoperative reaction, as shown by the absence of swelling and maintenance of good motion. The common experience was to have patients volunteer that they "had no pain" or "never had any pain" in the days immediately following surgery. After the initial two weeks almost all patients showed a tendency toward mild stiffening, but most of these improved with a little time. In three cases cortone by mouth in doses of 75 to 100 milligrams daily was given as a supplement with benefit. No particular difference was noted

in the cases with complete fasciectomy compared to those with partial excision. A patient with bilateral involvement received small injections of compound F into each operated finger approximately two and one-half weeks after surgery for beginning stiffness before systemic cortisone was started. No noticeable improvement occurred, probably because the reaction was general and the treatment too localized.

For Dupuytren's contracture, compound F as a local agent introduced into the operative wound appears to be a favorable adjunct in the immediate postoperative course. If there is pronounced tendency toward stiffening, supplementary systemic treatment with oral cortone can be instituted with benefit. In some cases stiffening seemed to recur when the systemic drug was discontinued too early.

Tendon Freeing

Of six patients all six were improved and there was one complication.

Patients treated after operation	6
Flexor tendon freeing after primary repair in digit	4 (6 tendons)
Flexor tendon freeing after adherence of tendons at fracture site of proximal phalanx	3 (5 tendons)

Results in general were good for this group of patients, as might be expected even without the use of compound F. In each instance, 0.2 to 0.3 cubic centimeter of the drug was injected into the wound of each digit at the time of closure. Early motion was started and all wounds healed *per primam*. A single complication occurred in a digit in which osteotomy of the proximal phalanx was done at the same time. The tendon remained quite free, but bony union was not complete after the end of three months. In two instances the flexor tendons were so roughened by scar that grafting would have been indicated under ordinary circumstances, but this was not done. In each case the result roughly equaled that obtained with the tendons showing less scar formation (Figs. 3-A and 3-B).

The principal advantage of using compound F in this group of cases seemed to be the fact that there was minimal postoperative pain and reaction and this allowed earlier exercise of the freed tendon.

Tendon Suture

Of four patients undergoing this procedure, the flexor tendons being involved in each case, all four were unimproved and there was one complication.

Secondary repair	3
Primary repair	1

Of the three cases of secondary repair, two were the rejoining of the flexor profundus tendon severed within the finger and one was a repair two weeks after a rupture of the juncture of a flexor tendon graft to its muscle above the wrist. Other than the fact that the patients did not complain of postoperative pain, there did not appear to be any improvement over what would be expected under ordinary circumstances.

The one case of primary repair was of a flexor profundus tendon of an index finger near its point of insertion. Following removal of the pull-out wire in three weeks, the tendon juncture apparently yielded to some degree and the tendon became adherent, since good flexion of the distal phalanx was not restored.

Postoperative Reconstruction

Of nine patients nine were improved and there was one complication.

Following our observation that compound F in a postoperative wound seemed to minimize the general reaction of the tissues to surgery, the drug was given a trial in the following nine types of reconstructive cases:

1. Arthrodesis of the wrist;
2. Arthrodesis of the wrist with capsulectomy of proximal finger joints;
3. Extensive extensor tendon freeing with fascial graft;
4. Reconstruction of flexor tendon sheath pulley in the palm with tendon graft;
5. Extensive freeing of flexor tendons in the hand and wrist, with capsulectomies in the proximal finger joints;
6. Arthrodesis of the middle finger joint and freeing of flexor tendons;
7. Arthroplasty of the proximal joint of a finger, with tendon freeing and fascial graft;
8. Primary repair for crush injury to fingers;
9. Secondary nerve and tendon repair in the palm.

In each case, depending upon the extent of the surgery, from 0.5 to 1.5 cubic centimeters of compound F was placed in the operative wound. Particular attention was then paid to the amount of postoperative pain and swelling. In each instance both were reduced to a minimal degree clinically. The most striking cases were the two wrist fusions which under ordinary circumstances would be associated with considerable pain and swelling during the first three to five days. Both patients had almost no swelling and neither complained of postoperative pain to the degree that would be expected. In all cases wound healing was *per primam*. The one complication in the series was a small hematoma in the palm of the patient with nerve and tendon repair. This was evacuated within the first week and healing progressed without delay.

Miscellaneous

Of four patients all four were improved and there were no complications.

Calcareous deposit in flexor carpi ulnaris tendon with acute symptoms	1
Mucous cyst of the finger	2
Flexor tendon grafting	1

In the patient with acute tendinitis with calcareous deposit 0.6 cubic centimeter of compound F was injected about the flexor carpi ulnaris tendon on the same day that spontaneous rupture of the lime accumulation occurred. Twelve hours later the patient was symptom-free and left the hospital.

The two patients who had mucous cyst received 0.1 cubic centimeter into the cyst. At the end of one week there was no evidence of the cyst ever having been present. In one, slight swelling recurred after three weeks and this was again injected. There has not been recurrence to date.

The patient with the flexor tendon graft showed good motion from the start. At the end of six months he was able to flex the middle joint 74 degrees and the distal joint 69 degrees voluntarily.

CONCLUSIONS

Compound F has been used as an adjunct in the treatment of seventy hand conditions with and without operation. There have been no complications which can be exclusively ascribed to the use of the drug. Compound F has the temporary effect of minimizing inflammatory reaction. It can in no sense be considered a cure. In cases of rheumatic origin, including arthritis, tenosynovitis, trigger finger, and the tendency of the fingers to stiffen following operations on Dupuytren's contracture, compound F is of value in temporarily ameliorating symptoms or in tiding the patient over postoperative difficulties. For major reconstructive procedures on the hand, compound F seems to be of value in minimizing the immediate postoperative reaction to surgery. In this limited series compound F did not appear to be of value in simple ganglia or in primary tendon repair.

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DISCUSSION

(*Continued from page 993*)

as those of Dr. Grant and Dr. Gonzalez. The work originally had been carried out in the peritoneal cavity and we expected to work on tendons later if the findings warranted. The work involved denuding the small intestine in the experimental animal and using ten milligrams of cortisone per kilogram of body weight intramuscularly each day. Repeated observations were made by successive laparotomies and the number and extent of adhesions were measured over a period of time. In essence, if cortisone was started on the day of the denuding operation, there was no difference between the experimental and the control groups. If the drug was taken for one week prior to operation, there was some difference. In no instance were adhesions in the peritoneal cavity prevented entirely. We did notice that, as the animals received the drug over a long period of time, there was a difference in wound healing, but this difference was not great. These animals were subjected to successive operations while they were on cortisone. The work on tendons was not undertaken, as we felt that the results of the work on the peritoneal cavity did not warrant it.

Dr. Howard's presentation was also most interesting. It may be that a drug of greater potency may be more successful. Any drug which will cut down inflammation locally and encourage early motion after operation should be a great benefit in surgery of the hand.

RUPTURE OF THE EXTENSOR POLLICIS LONGUS TENDON FOLLOWING COLLES' FRACTURE

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Since spontaneous rupture of the extensor pollicis longus tendon after fracture of the distal end of the radius is uncommon, the addition to the literature of three previously unreported cases seems indicated. The first case was reported in 1876 by Duplay, in a woman thirty-six years old. The literature has been reviewed from time to time and additional cases have been added. Kleinschmidt found twenty-five cases in 1929. McMaster, reporting a case in 1932, found twenty-seven others. Moore recorded three cases in 1936. By 1940, Kweder and Mitchell, reporting one case, were able to trace seventy. Smith added five cases in 1946, Weinberg added three cases in 1950, and Trevor, reporting shortly after Weinberg, added nine more, making a total of at least eighty-eight cases described in the literature.

A number of theories have been presented to explain the causes of the tendon rupture; it seems probable that no single theory, but a combination of theories, is the true explanation.

With fracture of the distal end of the radius, the possibility of injury to the extensor pollicis longus tendon is likely, because of the obliquity of the course of the tendon in the region of the fracture line. With a partial tear in the tendon and local ischaemia, after the initial hemorrhage, in and about the tendon, aseptic necrosis of the tendon may develop. If the tear and the necrosis are sufficiently extensive, rupture will follow.

In the three cases reported in this article, the patients had degenerative changes in the tendon which extended for more than 2.5 centimeters proximally from the transverse ligament. In all three patients, the rupture occurred at, or just proximal to, the distal edge of the transverse carpal ligament. In all three patients, the groove under the transverse carpal ligament was free of scar tissue and was easily identified. In one of the three patients, the rupture occurred between the second and third week of treatment, while the wrist was still immobilized in a plaster splint. In the third patient, the rupture occurred four months after injury and about two months after full use of the wrist and thumb had been allowed. Possibly premonitory symptoms had been present in this patient, for there had been persistent pain at the dorsum of the wrist from the time of the fracture to the rupture.

In all three patients, treatment consisted in the transfer of the extensor indicis proprius to the distal end of the extensor pollicis longus tendon. Exposure was obtained through an incision 3.8 to 5 centimeters long over the dorsum of the hand, running parallel to, and slightly to the radial side of, the second metacarpal. This incision gives good exposure to the distal ruptured end of the extensor pollicis longus, to the extensor indicis proprius tendon, and to the dorsal transverse carpal fascia with careful subcutaneous dissection. The incision can be elongated proximally and distally if need be. A second incision is made over the dorsum of the forearm proximal to the transverse carpal ligament, approximately mid-way between the radius and ulna. The distal end of the incision may be extended to the first incision if necessary, but it must extend sufficiently proximal to allow the location of the retracted proximal end of the ruptured extensor pollicis longus tendon. The ends of the ruptured tendon are freshened by means of cutting them transversely with a sharp knife. The extensor indicis proprius tendon is isolated and is divided approximately 1.3 centimeters proximal to the second metacarpophalangeal joint, and it is retracted through its sheath and is passed through the groove for the extensor pollicis

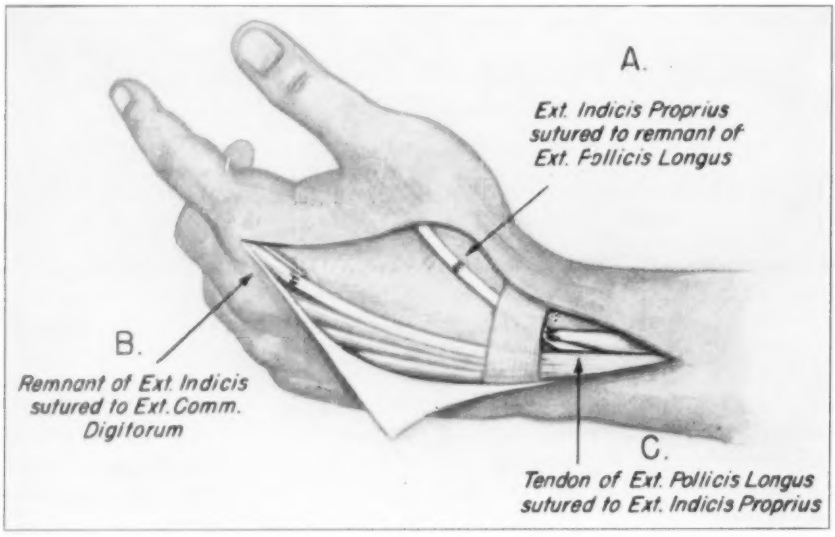

FIG. 1

Drawing illustrating method of repair.

longus tendon under the transverse carpal ligament. This canal can readily be found and should not be occluded by scar tissue, since the ruptured tendon will have been retracted into the forearm. A wire traction suture with a pull-out wire is passed through the end of the transferred tendon into the distal end of the extensor pollicis longus tendon and is carried out through the skin and tied over a button after the technique described by Bunnell. A slit is then made in the tendon of the extensor indicis proprius as far distal as possible, and the proximal end of the extensor pollicis longus tendon is sutured to this slit. A slit is then made in the extensor digitorium communis tendon and the remaining cut end of the indicis proprius tendon is sutured to this slit. The wound is closed in anatomical layers and a plaster splint is applied to maintain the wrist in partial extension and the thumb in neutral position. The cast should include the entire thumb and should remain in place for at least three weeks. After the removal of the cast and the traction wire, careful active exercises are instituted.

Full, active, strong extension has been obtained in every instance, and no loss of extension power has been demonstrable in the index finger.

A review of the literature reveals that use of the extensor digitorum communis tendon of the index finger for the transfer is common and that the extensor indicis proprius is occasionally used, but no mention is made of the suturing of the proximal end of the ruptured extensor pollicis longus tendon to the adjacent tendon transfer, nor is the remaining unsatisfied tendon at the point of division sutured to its adjacent tendon. Anatomically, the extensor indicis proprius re-enforced by the extensor pollicis longus should function with greater strength and dexterity than the slip of the extensor digitorum communis to the index finger. The extensor indicis proprius originates from the ulna and interosseous septum just distal to the extensor pollicis longus, whereas the extensor digitorum communis originates from the lateral condyle of the humerus primarily. Also, frequently in anatomical variations of the extensor indicis proprius slips are sent to the thumb to insert with the extensor pollicis longus.

CASE 1. A woman, seventy-four years old, was seen in 1948 with an impacted Colles' fracture of the left radius. Five weeks after reduction, and after the removal of the cast, a snap was felt at the base of

the thumb with immediate loss of thumb extension. At operation, the extensor pollicis longus tendon was found frayed out, with the rupture having taken place under the transverse carpal ligament.

CASE 2. A man, forty-eight years old, who was treated elsewhere for a fracture of the distal end of the left radius, was seen in 1950. Loss of extension of the thumb had become apparent near the end of the second week, just before removal of the plaster splint. The physician giving the original treatment did not recognize the pathological condition; and, as a result, repair was not attempted until two months later. At the time of examination, prior to operation, a mass could be felt in the mid-portion of the forearm. At operation, this mass proved to be the retracted proximal portion of the degenerated tendon surrounded by scar tissue. After the removal of scar tissue about the proximal and distal ends of the tendon, a gap 6.3 centimeters long was found. The extensor indicis proprius tendon was transferred as previously described and the proximal end of the thumb extensor was sutured to the transferred extensor indicis proprius tendon for increased strength.

CASE 3. A sixteen-year-old boy, who had had a fracture of the distal end of the radius which had been adequately treated, was seen in 1950. Rupture occurred four months after the fracture, when function of the wrist was practically normal. At operation, the rupture of the tendon appeared to have taken place under the transverse carpal ligament. A section nearly five centimeters long was frayed and degenerated, making resuture impossible. The extensor indicis proprius tendon was transferred, the transfer being passed under the transverse carpal ligament. The remaining proximal end of the thumb extensor was sutured to the extensor indicis proprius tendon in order to obtain increased strength.

Excellent function was obtained in each instance, and strength and function have remained good to this date. No loss of extensor strength of the index finger has been noted because of the transfer of the extensor indicis proprius tendon.

SUMMARY

Rupture of the extensor pollicis longus tendon occurs occasionally following a fracture of the distal end of the radius. Rupture is probably due to damage to the tendon at time of fracture by the sharp edges of the fracture fragments with further attrition of tendon strength by aseptic necrosis of a section of the tendon.

The loss of tendon substance due to degeneration may be sufficiently great to necessitate tendon transfer. The extensor indicis proprius tendon can be used for transfer without loss of strength in the index finger, and it has adequate power to produce apparently normal extension of the thumb. Satisfactory transfer can be obtained by the use of pull-out wire sutures according to the technique described by Bunnell.

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PARTIAL RUPTURE OF THE TENDON OF THE POSTERIOR TIBIAL MUSCLE

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Pain, swelling, and disability of the ankle due to a partial rupture of a tendon in a synovial sheath has not, to the author's knowledge, been previously described. The report of such a case should be of interest.

The patient was a steamfitter, forty-five years old, who complained of pain, swelling, and disability in the medial side of the left ankle.

The past history was irrelevant except for an operation eighteen years before upon this left ankle when the author removed some detached bone fragments from beneath the lateral malleolus and repaired a sprain fracture and an old tear of the calcaneofibular ligament. The foot had been serviceable ever since, but not quite normal—perhaps a little weak.

A little over six months before admission, while walking down an unfinished stairway with two pieces of iron pipe on his shoulder, he had slipped and, in order to avoid falling, he had jumped about four steps and landed heavily on the left foot and turned the ankle slightly, injuring the outer side. The pain in the lateral aspect of the ankle subsided after a few days and it did not stop him from working.

About ten days after the accident, pain and swelling developed on the medial aspect of the ankle. This was aggravated by working and especially by climbing stairs, and at times the pain extended up the leg to the knee. The man was unable to go up or down steps on his toes, but had to put his whole left foot on the step. Working on a ladder also caused much pain. Striking his foot against a small object while walking produced sharp pain in the ankle and at times this caused him to stumble or even to fall. The swelling, pain, and tenderness decreased after rest in bed, but they did not completely subside and were increased after working or other activity on his feet; the swelling had increased slowly during the past few months.

FIG. 1

Partially torn posterior tibial tendon exposed at operation. Note the loose tab behind the malleolus and the hypertrophied distal portion of the tendon. The thickening and hyperplasia of the synovial sheath are not well shown, but the hemostat is shown grasping a small synovial villus.

As the symptoms persisted, he reported the injury to the insurance company and was sent to Dr. H. R. McCarroll about a month after the accident. He was treated conservatively for over five months and then hospitalized. The writer saw him in consultation and, when operation was decided upon, was asked to perform it. Dr. McCarroll agreed.

Physical examination revealed a moderate swelling behind, below, and distal to the medial malleolus. This swelling followed roughly the course of the posterior tibial tendon and was boggy and not definitely fluctuant. There were no signs of acute inflammation; but there was slight tenderness and a moderate amount of pain was elicited by forcibly inverting, everting, or dorsiflexing the ankle. No crepitus was felt over the mass when the foot was moved actively on the leg, and such movements were not painful or limited.

Roentgenograms revealed nothing abnormal except the soft-tissue swelling; routine laboratory and general physical examination revealed nothing else abnormal.

No definite diagnosis could be made and it was decided that the tendon should be explored. It was expected that a tumor or a chronic synovitis of the tendon sheath would be found.

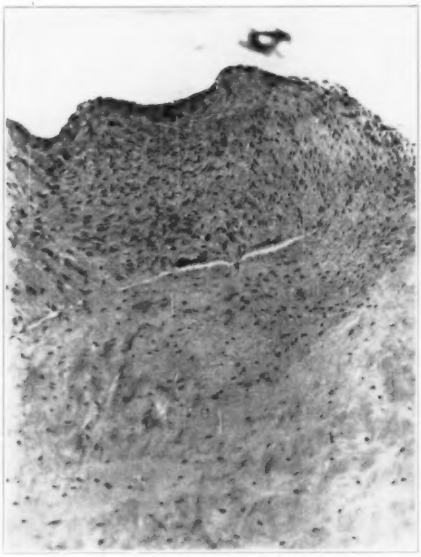

FIG. 2-A

FIG. 2-B

Fig 2-A: Low-power photomicrograph of torn end of tendon, showing increased cellularity and hypertrophy of this portion of the tendon.

Fig. 2-B: Lining of synovial sheath. Note round-cell infiltration and proliferation of lining cells and villus formation. One small nodule of round cells is shown.

At operation the sheath of the posterior tibial tendon was exposed through an incision directly over the swelling and was found to be moderately enlarged and distended with fluid. When the sheath was incised, a few cubic centimeters of straw-colored fluid escaped. The wall was moderately thickened, and the lining surface was hyperplastic and exhibited some rugae and villi.

The tendon was enlarged to over twice its normal diameter in the portion distal to the medial malleolus and the area of thickening was about 7.5 centimeters long. Proximal to the thickening, the tendon was only about one half of its normal diameter in the portion where it curved around the malleolus, and just proximal to this there was a loose tab of tendon, about 3.75 centimeters long, which comprised about one half the thickness of the tendon. This was free in its distal portion, and the free end was smooth and rounded. Apparently the tendon had been torn about halfway through and then had been split proximally for about five centimeters (Fig. 1).

The loose tab of tendon was excised, and a smooth sloping base remained. Then the thickened distal portion was pared down until it was approximately the thickness of the normal tendon, and as much of the thickened synovial lining of the tendon sheath was removed as was possible without undue trauma. The sheath was then closed; the deltoid ligament was repaired with interrupted sutures of fine silk; the wound was closed in layers; and the foot was immobilized in the neutral position in a walking plaster boot which extended from the tibial tubercle to the toes. At the end of three weeks, the plaster boot and skin sutures were removed, and the patient was encouraged to exercise and to use the foot.

He was given a Thomas heel and a soft rubber arch pad. The convalescence was rather slow, probably because he had to return to heavy work involving lifting and climbing, but he has been working for several months now (ten months after the operation). He still complains of some pain after a hard day's work.

At a more recent examination, eighteen months after the operation, he apparently had from 10 to 15 per cent disability at the ankle.

DISCUSSION

At operation, repair of the tear was considered, but it was felt that this would cause an enlargement of the tendon at the point where it passed under the malleolus and this was not desirable. It was felt also that the small tendon which was left would probably hypertrophy to a point where it would be capable of meeting the demands to which this tendon is ordinarily subjected; this seems to be the case. It is interesting to note that the tab was

atrophic and the proximal portion of the tendon was about normal, while the part distal to the tear was hypertrophied. This condition was probably due to the fact that the blood supply was more abundant near the insertion of the tendon.

EWING'S TUMOR OF THE TALUS (ASTRAGALUS) SIMULATING ASEPTIC NECROSIS*

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In children spontaneous aseptic necrosis of bone, or osteochondrosis, denotes a disease process the etiology of which is unknown. It is thought to be the result of circulatory insufficiency, and it occurs characteristically in some of the epiphyses of long bones and also in several of the small bones of the extremities. This case report of aseptic necrosis of the talus, probably caused by Ewing's tumor, is presented as an unusual localization of the process with unusual etiology. Complete postmortem observations are included, inasmuch as relatively few autopsy reports of Ewing's tumor are available in the literature. No localization in the talus of spontaneous aseptic necrosis or of Ewing's tumor has been noted previously.

REPORT OF A CASE

A three-year-old boy complained of a painful limp of the left leg without previous trauma or infection. The limp persisted for a few weeks, at which time physical examination revealed the following: The systemic findings were normal. The left leg showed mild atrophy, with spasm of the peroneal muscles, and at the left ankle there was thickening and mild tenderness with limitation of motion due to muscle spasm. Roentgenograms (Figs. 1-A and 1-B) showed demineralization of the talus and minimal thickening of the soft tissue. The sedimentation rate was normal, and a tuberculin test gave negative results. The patient was afebrile and without systemic symptoms, and he remained so for two-and-a-half years while the lesion of the talus

FIG. 1-A
Left talus.

FIG. 1-B
Right talus.

Roentgenograms taken in January 1949. The left talus shows demineralization and a change in contour which may be due to compression, but no definite aseptic necrosis or signs of bone destruction are present.

* Aided by a grant from the Playtex Park Research Institute.

FIG. 2

FIG. 3

Fig. 2: Roentgenogram taken in February 1949. Diffuse aseptic necrosis is now obvious. The changes in contour of the talus have increased. No signs of a destructive bone lesion can be made out.

Fig. 3: Roentgenogram taken in April 1949. Further change in contour and increase in density mark the progress of the aseptic necrosis. Areas of decreased density indicate some bone resorption as well, but still no signs of bone destruction are evident.

Fig. 4: Roentgenogram taken in April 1951. Little change has occurred after two years. The film was taken just before the facial tumor appeared. Subsequent films did not show significant change.

FIG. 4

was observed and treated. The treatment consisted in immobilization of the ankle with casts for about three months, followed by a program of non-weight-bearing in a patten-bottom splint. The patient's physical condition during this period was essentially unchanged, but serial roentgenograms showed progressive aseptic necrosis of the talus, without evidence of active destruction or of healing (Figs. 2, 3, and 4). His general health was good.

When the patient was five years old, a painless lump, which grew rapidly, developed suddenly over the left eye. He became febrile and anorexic, and began to vomit all food. The lump became painful and hyperaesthetic, and he began to see double. About two weeks after the lump appeared, he was hospitalized and physical examination revealed a large firm mass involving the right orbit and zygoma, with proptosis. Except for increased muscle atrophy, the left lower extremity showed little physical change during the entire period of his illness. Biopsy of the temporal mass revealed a malignant tumor, and a therapeutic regimen of roentgen therapy and chemotherapy was begun. The tumor mass shrank rapidly, but the patient became cachectic and began to have diffuse bone pain. Two months after the facial mass first appeared, a large abdominal mass developed, and flaccid paraplegia followed. Many bony and pulmonary metastases appeared, and after two weeks, during which his course was rapidly downhill, he died.

Postmortem Examination

Complete postmortem examination revealed widespread dissemination of tumor tissue. This tissue was firm and nodular, and it exuded a milky fluid on compression. The largest mass of tumor extended as a sheet surrounding the pelvic vessels, aorta, and vena cava and reaching into the mediastinum. It covered the lumbar and thoracic vertebral bodies anteriorly and laterally and extended through the spinal foramina to involve the spinal cord in the lumbar region. It did not infiltrate the kidneys, adrenals, or other abdominal viscera, except for one solitary nodule in the liver. The retroperitoneal lymph nodes were indistinguishably incorporated into the main mass of tumor. The lungs were peppered with large and small tumor nodules which occurred both on the surface and in the parenchyma. The skeleton also showed widespread involvement

by tumor. The sternum, ribs, vertebrae, pelvis, femora, and cranial bones were infiltrated interstitially and subperiosteally, and often contained nodular subperiosteal tumor and reactive bone in deposits one to two centimeters in thickness. Small nodules of tumor also were present in many areas of cancellous bone, and in the femoral medullary cavity. The subperiosteal deposits, especially in the right side of the pelvis and in the vertebrae, were continuous with the overlying nodular tumor mass in places.

The talus on the right showed no involvement by tumor. The left talus was smaller and flatter than the right (Figs. 5-A and 5-B), and its cartilage was pale yellow. Two small hemorrhagic areas were found on its lateral surface. There was thickening and fibrosis of the surrounding soft tissue and synovial membrane and slight involvement by tumor of the non-cartilaginous surface. Longitudinal serial blocks revealed complete disarrangement of the trabecular structure of the bone, and, after staining, masses of necrotic bone, necrotic tumor, and viable tumor could be seen grossly.

Microscopically, the tumor was similar in all areas (Fig. 6). It extended in large sheets or nodules and was extremely vascular. It provoked only slight fibrous-tissue reaction at its periphery, but in the bone, es-

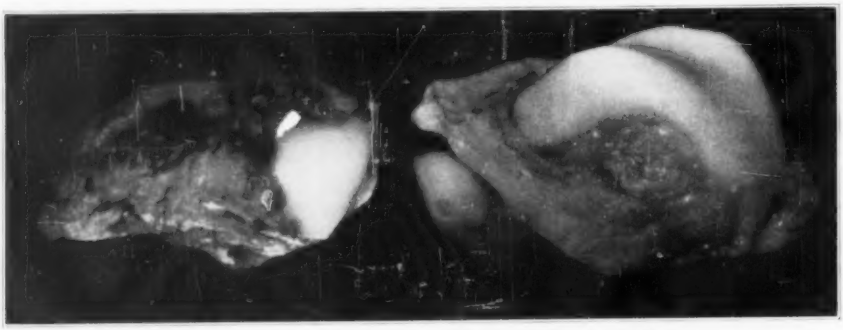

FIG. 5-A

Left talus.

FIG. 5-B

Right talus.

The left talus is smaller than the right, and its cartilage, while intact, is discolored. Anteriorly, the fibrosis of soft tissues can be seen. Medially, there is a small nodule of hemorrhagic tumor tissue.

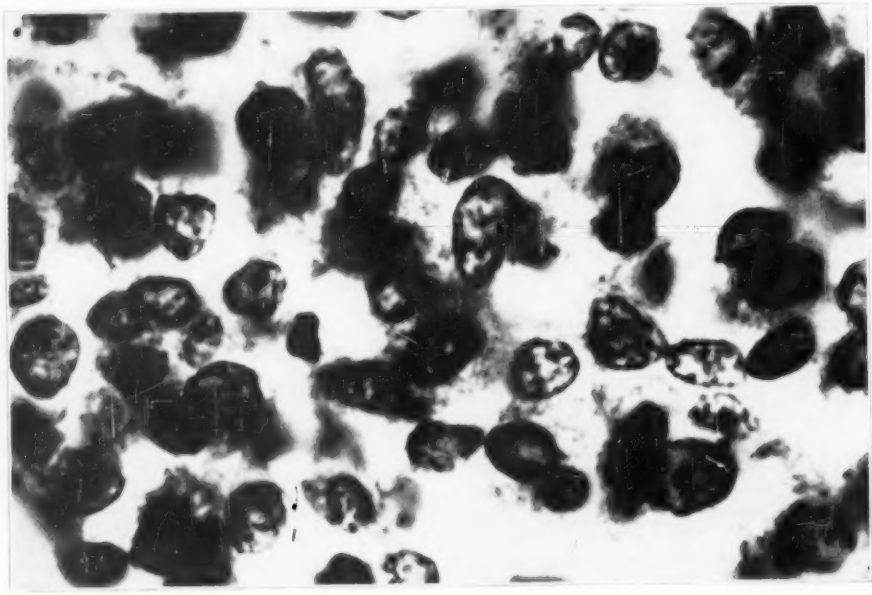

FIG. 6

Section of tumor from lung metastases (× 1700). The cells are rather uniform, with oval or spherical nuclei and scant cytoplasm. The cell boundaries are indefinite.

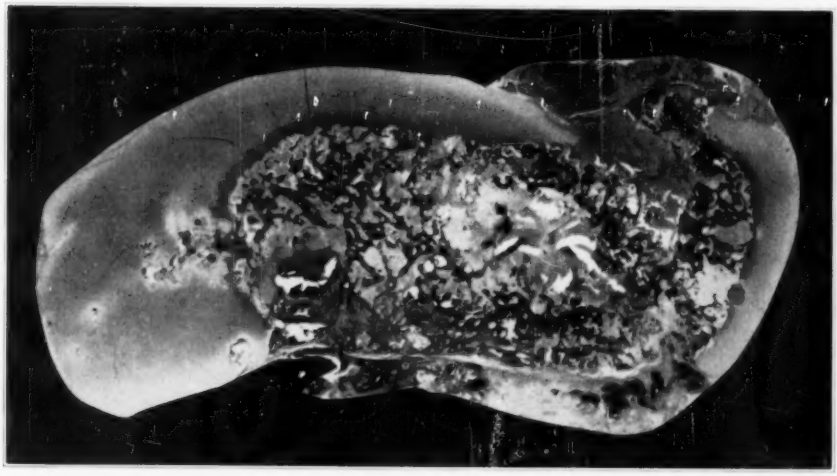

FIG. 7

Section of left talus. All the marrow space is filled with tumor. Viable tumor tissue is present on the inferior surface. Calcification is evident in the necrotic tumor tissue in the center and anteroinferior part of the talus. The disruption of trabecular pattern is obvious. Most of the trabeculae are necrotic.

pecially subperiosteally, large deposits of immature reactive bone occurred where the tumor infiltrated. No intercellular material was produced by the tumor cells. Necrosis was not extensive in the tumor masses, but occurred focally. The tumor cells were uniform, closely aggregated, and without rosette formation. They measured ten to twelve micra in diameter, and had scant cytoplasm and indefinite cell boundaries. The nuclei were ovoid or spherical and often contained one or two nucleoli.

Sections of the left talus (Fig. 7) showed nearly complete involvement by tumor, which infiltrated between all trabeculae and extended through the periosteum but left the cartilage intact. Much of the tumor tissue was necrotic, but several viable areas were present, and a few vessels contained tumor cells. Most of the bone showed aseptic necrosis, and there was great distortion of the trabecular structure. A few foci of calcification were seen in the necrotic tumor tissue. Some trabeculae were overlaid with deposits of reactive bone which occasionally showed aseptic necrosis. These laminae of new bone varied in structure and staining qualities. The variations indicated different periods of deposition. All of the new bone in the talus sections was more mature than the repair bone deposited in other bony lesions.

DISCUSSION

Three cases which have been called spontaneous aseptic necrosis of the talus have been described in the literature.[1,2] In none of these were histological studies presented. In each of these the published roentgenogram and brief history suggest that the process at hand was either sepsis, osteochondritis dissecans, or tuberculosis. In the present case, had postmortem studies not been done, the talar lesion would have been considered an aseptic necrosis unrelated to the malignant tumor. The object lesson to be gained is that an unusual localization of "spontaneous" aseptic necrosis should evoke a suspicion of unusual etiology.

A controversy over the stem cell of Ewing's tumor still exists. There are some pathologists, notably Willis, who favor the opinion that most Ewing's tumors are not primary in bone, but represent metastatic involvement by such malignant neoplasms as neuroblastoma or lymphosarcoma. He questions the existence of any distinct entity, as described by Ewing, and believes it represents a typical metastatic involvement. In the light of this dissent from prevailing opinion, based on a small number of complete autopsy reports and in the absence of distinctive tumor cytology, it becomes important to consider whether the talar lesion in this case was the primary tumor, or whether it repre-

sented metastasis in a bone which was undergoing aseptic necrosis. The rare incidence of Ewing's tumor in the general population and the rarer occurrence of spontaneous aseptic necrosis of the talus make a coincidence of the two lesions extremely unlikely. The progression of the talar lesion over a period of two and a half years also indicates primary involvement as opposed to sudden infiltration by tumor of a pathological area in bone. The absence of an obviously primary tumor in the abdomen, or elsewhere, must be emphasized. Moreover, the presence, in the talus, of large masses of necrotic tumor, some of which showed calcification in addition to necrotic mature bone and necrotic repair bone, argues for a longer period of involvement of the talus by tumor compared with the involvement of other bones.

The processes of tumor infiltration, necrosis, and reaction in the talus were different from those in other bones. Elsewhere, extensive subperiosteal and interstitial infiltration, with production of immature reactive bone, indicated that the lesions were much shorter-lived than that in the talus. All the bone lesions except that of the left zygoma and the talus showed reactions of similar timing. The zygomatous lesion histologically also did not resemble the talar involvement in chronicity, but the trauma of surgery and roentgen irradiation complicated the interpretation of the timing of this lesion.

It is difficult to explain why a tumor should remain dormant for more than two years and then show extensive metastatic spread. However, this phenomenon has been observed previously. In this instance, it may well be ascribed to the occurrence of aseptic necrosis, which may have destroyed much of the original tumor and provided no means for dissemination until the circulation began to be re-established. The fact that no great proliferation of tumor occurred in the talar area may also be explained in this way. While absolute proof is lacking that this talar lesion represents primary involvement by tumor with subsequent aseptic necrosis, we feel that the evidence favors this explanation rather than a diagnosis of metastatic malignancy in an area of aseptic necrosis.

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A MECHANICAL AID TO WALKING

A Crab Crutch with a Universal Joint

BY BORDEN BACHYNSKI, M.D., MEMPHIS, TENNESSEE

From the Campbell Foundation, Memphis

The modified crab crutch is presented here as an aid to walking. It was first constructed for use in the rehabilitation of young poliomyelitic patients when diffuse involvement of the limbs made them unable to use the conventional crutch because of its unstable one-point fixation on the ground when various angular thrusts are put upon it. In the crutch shown, the stability of the tripod has been greatly increased by the insertion of a universal joint between it and the crutch proper. As the crutch is lifted up and swung forward, the tripod hangs directly downward from the universal joint and grips the ground evenly, thus compensating for any angular thrust put on the crutch. Once the tripod is "seated" on the ground, the gait is completed through this same joint without moving the stationary tripod (Fig. 2).

Fig. 1

This crutch is easily and inexpensively constructed. The universal joint is a simple plumbing fixture, a shower-head. A tripod is attached at one end. The crutch at the other end, of tubular metal, is easily tapped and screwed into the shower attachment, which is already tapped. The friction is eliminated by removing the inner rubber gasket, thus producing the desired free-wheeling universal joint.

Fig. 2

POSTEROLATERAL FUSION OF THE LUMBAR AND LUMBOSACRAL SPINE

BY MELVIN BRENT WATKINS, M.D., NEW YORK, N. Y.

Fusion of the spine is usually accomplished by means of the Hibbs or the Albee technique, or a modification of one of these. The posterior mid-line incision allows an easy access to the spines, laminae, and articular facets. There are patients, however, in whom particular problems of the lumbar or lumbosacral spine make it difficult, if not impossible, to fuse successfully through the usual posterior approach. Laminal defects, either congenital or those resulting from laminectomy, may be too extensive to bridge

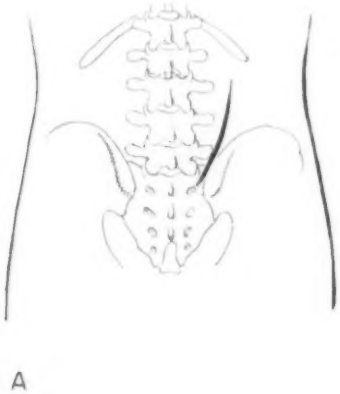

FIG. 1-A

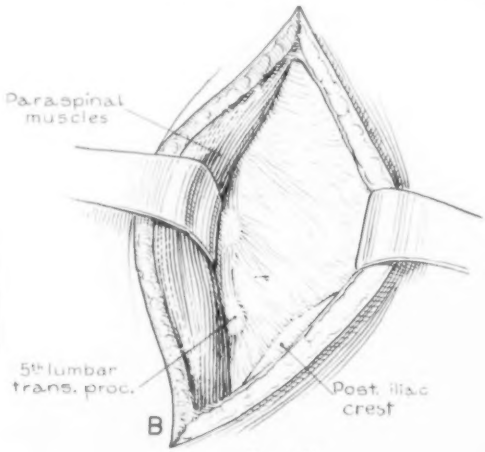

FIG. 1-B

Fig. 1-A: Diagram shows the skin incision.

Fig. 1-B: Exposure of the posterior iliac crest and the tips of the transverse processes of the fourth and fifth lumbar vertebrae is shown.

FIG. 2

Fig. 2: Drawing shows an iliac graft in position for fusion from the fourth lumbar to the first sacral vertebrae. Note that the graft is in contact with the transverse process of the fourth lumbar vertebra. The capsule of the facet of the third and fourth lumbar vertebrae should be carefully preserved. The graft has been secured with one screw in the base of the transverse process of the fifth lumbar vertebra.

adequately with bone. Patients with congenital malformations may have associated neurological anomalies which are contra-indications to exposure of the spine through a posterior incision. Pseudarthrosis, particularly in the lumbosacral region, remains a problem in spite of modified methods of fusion and improved operative technique. Attempts to repair a pseudarthrosis are not always successful, and the incidence of failure increases with each successive attempt at repair. The complication of wound infection adds to the difficulty of obtaining fusion in an environment of devitalized and relatively avascular tissues. Tuberculosis involving the posterior elements of the spine is difficult to treat surgically, for one hesitates to attempt a fusion in an area of tuberculous disease. Problems such as these have led to an investigation of the posterolateral region of the spine as a possible area for fusion.

The posterolateral region of the lumbar and lumbosacral spine, which consists of the articular facets, the pars interarticularis, and the dorsal aspect of the transverse processes, has sufficient bone surface for the bridging of the vertebrae with bone grafts. The surrounding muscles provide a healthy soft-tissue environment, and fusion is further favored by the position of the grafts near the center of anteroposterior motion of the spinal column.

Access to this part of the spine is sometimes possible from a mid-line approach by making transverse incisions in the fascia of the paraspinal muscles. A more adequate and more satisfactory exposure is obtained through the posterolateral incision to be described. This approach has been used in ten patients presenting difficult problems in fusion. The description of the procedure and the discussion of the cases are submitted as a preliminary report.

OPERATIVE TECHNIQUE

The exposure is made through a longitudinal skin incision along the outer border of the paraspinal muscles, curving medially at the distal end across the posterior crest of the ilium. After the lumbothoracic fascia has been divided, the plane of cleavage is established between the border of the paraspinal muscles and the fascia overlying the transversus abdominis muscle. The tips of the transverse processes can be palpated in the depths of the wound. At this point, the posterior crest of the ilium is exposed by subperiosteal dissection and is removed almost flush with the sacro-iliac joint, sufficient bone being taken to provide one or two grafts of the desired length. Removal of the iliac crest facilitates exposure of the spine. By the retracting of the sacrospinalis toward the mid-line,

FIG. 3-A

FIG. 3-B

Fig. 3-A: Roentgenogram shows tuberculosis of the upper sacral vertebrae and posterior elements of the fifth lumbar vertebra on the right side. The operative site on the left was free of disease.
Fig. 3-B: One year later, laminagrams revealed solid fusion.

TABLE I

INDICATIONS FOR POSTEROLATERAL FUSION IN TEN PATIENTS *

Case	Sex	Age	Operative Indication	Original Diagnosis	Previous Operations
A. M.	F	32	Pseudarthrosis of the fourth and fifth lumbar vertebrae.	Unstable lumbosacral spine	4
M. M.	F	48	Pseudarthrosis of the fifth lumbar and the first sacral vertebrae.	Unstable lumbosacral spine	5
M. H.	F	52	Pseudarthrosis of the fourth and fifth lumbar, of the fifth lumbar and first sacral vertebrae.	Unstable lumbosacral spine	4
H. R.	M	28	Pseudarthrosis of the fourth and fifth lumbar vertebrae.	Tuberculosis	4
H. P.	M	26	Pseudarthrosis of the fourth and fifth lumbar, of the fifth lumbar and first sacral vertebrae.	Tuberculosis	5
P. T.	M	28	Pseudarthrosis from the second lumbar vertebra to the first sacral vertebra.	Tuberculosis	3
A. H.	F	27	Unstable lumbosacral spine after laminectomy.	Disc lesion	3
D. J.	F	26	Unstable lumbar spine after laminectomy.	Disc lesion	4
M. P.	F	25	Tuberculosis of posterior portion of the spine.	Neoplasm	1
A. C.	F	35	Tuberculosis of laminae and sacro-iliac joint.	Tuberculosis of laminae and sacro-iliac joint	1

* Five of the patients in this series were from the New York Orthopaedic Hospital, Columbia-Presbyterian Medical Center, New York, N. Y.

Four patients were from the Orthopaedic Section, Veterans Administration Hospital, Kingsbridge, Bronx, New York.

One patient was from the Grasslands Hospital, Valhalla, New York.

the transverse processes are denuded of their dorsal muscle and ligamentous attachments; and the articular facets are exposed by excising the joint capsule. The cartilage is removed from the facets and, with an osteotome, the area is leveled down to allow the graft to fit snugly against the facet, the pars interarticularis, and the base of the transverse process. The facets are then comminuted with a small gouge or osteotome, and bone chips are turned up and down from the facet area, upper sacral area, and transverse processes. The graft, when rotated 90 degrees from its original position on the ilium, fits well against the exposed spine and closely follows the lumbosacral angle. The graft may be secured by a screw inserted at an angle of 45 degrees into the base of the transverse process at one or more levels, depending on the extent of the fusion. Additional ribbons and chips of cancellous bone are removed from the ilium and are packed about the graft. The paraspinal muscles fall into position over the area of fusion, the wound is closed, and a pressure dressing is applied.

The indications for the operative procedure in ten patients are shown in Table I. In two patients with tuberculosis of the posterior elements of the spine, the operation was performed as a primary procedure after a diagnostic exploration. In six patients with pseudarthrosis at one or more levels, fusion was obtained by means of this method after several unsuccessful attempts by means of the posterior approach. In two patients, the operation was used to stabilize a structurally defective lumbosacral spine resulting from extensive laminectomy. A total of twenty-four joints were fused. A hemifusion was done in nine patients, and in one patient grafts were placed bilaterally through two separate incisions. All the patients have been followed for over one year postoperatively; the longest follow-up is four years.

RESULTS

There were no wound infections in these paraspinal incisions. A hematoma at the lower end of one incision was aspirated five days postoperatively, and the wound healed without further complication. None of the patients has complained of tender postoperative scars.

The clinical improvement in nine patients has been gratifying. In one patient with tuberculosis of the spine and sacro-iliac joint, continued bed rest has been necessary because of the inability to control the tuberculous disease in the sacro-iliac joint. Three patients with tuberculous spines had been confined to bed for six, nine, and eighteen months, respectively, with pseudarthroses which had defied one or more attempts at repair. These patients became ambulatory and were returned to light work. One severely disabled patient was doing her own housework after six months. Four patients who had severe symptoms before the operation have returned to moderate activity with limitation on bending and lifting. One patient in whom the fusion was successful is ambulatory but is restricted in her activity because of a persistent tuberculous abscess.

FIG. 4

Roentgenograms showed that the patient had pseudarthrosis at the fourth and fifth lumbar vertebrae and fifth lumbar and first sacral vertebrae, with spondylolisthesis at both levels. A biplane bending roentgenogram, made one year after operation, revealed solid fusion.

Sufficient time has not elapsed for definite evaluation of the fusion in all of the patients. Surgical exploration, which the author feels is the only certain method of detecting bone fusion in the spine, has not been done and would hardly be advisable in these patients who have been subjected to so much surgery. Biplane bending roentgenograms have been made in six patients, and in one a laminagram has been helpful. Six of these patients had lumbosacral fusions, and in one the fusion extended from the second lumbar vertebra to the sacrum. Five of the lumbosacral fusions are solid. Roentgenograms of the patient in whom the fusion extended from the second lumbar vertebra to the sacrum revealed partial absorption of the graft from the level of the second lumbar to the fourth lumbar vertebrae. Two of the patients showed questionable motion on roentgenographic examination. Both of these patients, however, are asymptomatic and are doing their usual housework. Three patients with tuberculosis of the spine have not had bending roentgenograms made, but in one of these a laminagram reveals a continuous fusion.

DISCUSSION

Exposure of the spine lateral to the articular facets is thought to be difficult, if not hazardous, because of the excessive bleeding. Anatomically there is no basis for undue apprehension in operating in this region. The paravertebral muscles are supplied by small branches from the lumbar arteries which enter the muscle mass just lateral to the articular facets. These vessels with their accompanying veins are responsible for the brisk bleeding one occasionally encounters in exposing the facets in the usual Hibbs fusion. A few fairly

large veins are often present in the subcutaneous fat and along the lateral border of the paravertebral muscles. No vessels of sufficient size to cause troublesome bleeding were seen during the operations in this series.

A hemifusion was done in nine of these patients. In five patients, the operation was in conjunction with a posterior exploration, and bilateral fusion was thought to entail too much surgery. In two patients with tuberculosis of the posterior elements of the spine, a hemifusion was necessary, as only one side was free of disease. Bilateral fusion would have been preferable; this can be done in some cases at one operation or in two stages. In the one bilateral fusion in this group, the operative time was about three and one-half hours, and the postoperative course was uneventful. A recent patient who is not included in this series had a bilateral fusion as a primary procedure and has had no complications either at operation or postoperatively.

No definite postoperative routine has been established for patients of this type, as each patient is an individual problem. In two, a plaster-of-Paris spica was applied for postoperative immobilization; and in eight, either a spinal brace or a re-enforced corset was used. The average period of postoperative recumbency was eight weeks, and a brace or corset was worn for a minimum of six months.

A SIMPLIFIED LATERAL-VIEW CASSETTE HOLDER FOR USE DURING HIP-NAILING

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The holding of the x-ray cassette when the lateral exposure required in the hip-nailing procedure is taken has always been regarded as a hazardous chore. Rowe [1] has shown that the person holding the cassette for the taking of the lateral view during the average hip-nailing receives three times the daily dose in roentgen units considered safe by the Atomic Energy Commission.

Several lateral-view cassette holders have been developed recently which make it no longer necessary for a person to hold the cassette and to risk overexposure to roentgen rays. The purpose of this short paper is to introduce a very simple and inexpensive cassette holder which has been used with satisfaction for several months.

The lateral-view cassette holder (Figs. 1 and 2) is merely two metal C clamps welded together at right angles, with the addition of a piece of round metal, three-eighths of an inch in thickness, welded to the lower jaw of the cassette-holding C clamp (Fig. 1, *A*). This is to compensate for the offset caused by the depressed posterior aspect of most x-ray cassettes.

TECHNIQUE

In the using of this simplified lateral-view cassette holder, the C clamp holds the cassette with more stability if the patient is positioned as far to the opposite side of the fracture table as is practical. The C clamp will then grip the cassette as far laterally as possible on the affected side (Fig. 2).

FIG. 1

FIG. 2

Fig. 1: The simplified lateral-view cassette holder is shown. *A* indicates the added piece of round metal, three-eighths of an inch in thickness, which compensates for the offset caused by the depressed posterior aspect of the x-ray cassette.

Fig. 2: The simplified lateral-view cassette holder is shown in place holding the cassette for the making of the post-reduction x-ray. (The cassette is shown before the application of the sterile drapes.)

After the post-reduction x-rays have been taken, the C-clamp holder is sterilized and placed on the fracture table over the sterile drapes. All other lateral views are taken by dropping the non-sterile cassette into a sterile Mayo stand cover before the placing of the cassette in the sterile C-clamp holder.

CONCLUSIONS

This simplified C-clamp holder has the following desirable attributes:

1. It may be used with facility because of its mechanical simplicity;
2. It is easy to sterilize;
3. It is possible to maintain good sterile technique throughout the procedure;
4. It is durable;
5. It is inexpensive, for the parts may be purchased for a nominal sum at any good hardware store;
6. It is easy to make, for it requires only that the parts be welded together in two places.

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REPORT OF A TOUR OF CONSULTATION TO THE MEDICAL INSTALLATIONS OF THE FAR EAST COMMAND *

BY MATHER CLEVELAND, M.D., NEW YORK, N. Y.

This consultant reviewed the reports of the other consultants who were sent to the Far East Command, which have been circulated by the Society of Medical Consultants. Certain questions were raised, some of which may be answered partially here. Any given consultant can only report on the situation as it existed at the time of his relatively brief visit. The tour described herein extended from April 5 to May 22, 1953.

Mobility of Army Hospitals

The Korean War had for many months had a stabilized front without movement forward or back. On this account, forward hospitals might seem to have lost their mobility. However, the mobile Army surgical hospitals had just completed a practice forward move, without interruption of service, and had then resumed their former sites. No Army hospital at any time can possess and keep enough vehicles immobilized and ready to move it instantly.

Regular Army Medical Officers in the Far East

One consultant observed recently that the percentage of medical officers who were of the Regular Army was only 3 per cent. He may have been misinformed or misquoted. The total number of medical officers in the United States Army was 5,734 as of March 16, 1953. Of these, 1,759, or 31 per cent., were Regular Army officers.

In the Far East Command there were, for the period of this report, 1,083 medical officers. From October 1952 through February 1953, there were from 163 to 168 regular Army medical officers, or approximately 15 per cent. of the total.

Since a very high percentage of the Regular Army medical officers are of field grade, there are a limited number of jobs available in the theater of operations for officers of their rank. There can be no question that the elements of military surgery and medicine are best learned in an active theater of operations and it is to be hoped that every medical officer who expects to make his career in the Medical Corps of the Army will be given the privilege of serving overseas when there is action. It is a priceless opportunity to learn and should not be considered in any other light.

Previous Training of Orthopaedic Surgeons in the Theater

There were approximately thirty-eight medical officers with an M.O.S. (Medical Officers Specialists') rating of 3153 (orthopaedic surgeon). Five of these officers are diplomates of The American Board of Orthopaedic Surgery. Twenty of them have completed or practically completed their training and most of these will, in time, be eligible to take Part II of the examination given by The American Board of Orthopaedic Surgery.

From September 1950, this theater has been extremely fortunate to have had the services of Col. Oral Bolibaugh, a thoroughly trained Regular Army orthopaedic surgeon who has had long experience, from 1917 to this date, in the treatment of battle casualties. Col. Bolibaugh has been able to supervise the younger and less experienced orthopaedic surgeons almost since the onset of the Korean War. This fact is, in no small measure, responsible for the almost uniformly excellent care which has been afforded to those of our battle casualties with wounds involving bones and joints.

At the present time there are, in all probability, an adequate number of orthopaedic surgeons in the theater; but, with rotation of personnel, there will be a continuing demand for trained officers in this specialty.

Blood Program

At the Sixth Army Medical Depot in Yong Dong Po, blood arrives from the Zone of the Interior within five to seven days after it has been withdrawn. Automatically, 240 units arrive daily and 800 to 1,400 units are kept on hand,—approximately four days' supply. Tokyo keeps 400 to 700 units on hand,—two days' supply.

Blood is drawn in Japan, in part from Japanese civilian donors. No out-dated blood is issued, but blood approaching its date-line is issued to the Republic of Korea Army Medical Department and to Korean civilian hospitals. There seems to be no likelihood at present of instituting a Korean blood program.

No unusual reactions from administration of blood that is approaching or past its date-line have been reported, although there is inevitably 30 per cent. of the blood received which approaches date-line, having been kept as surplus because of possible need if fighting flares up. There is no actual waste, since our allies, the Koreans, use it with great benefit to their wounded.

* Submitted to the Surgeon General, United States Army.

I was told that transportation by jeep caused no deterioration of the blood. Blood is available at battalion aid stations by call to the clearing station on an anticipatory basis.

It seemed almost incredible that blood from New York or Boston could be in Korea five to seven days after it had been withdrawn. This blood program is one in which the Red Cross and the Army Medical Corps may justifiably take great pride.

On reporting to Eighth Army Headquarters, Col. Bohlbaugh and I met Gen. Holmes Ginn, Eighth Army Surgeon, who assigned Col. John Kemp Davis, Surgical Consultant, Eighth Army, to conduct us to various Army medical installations. Col. Davis arranged a profitable and expeditious trip.

Korean Medical Officers

At Ninth Corps Headquarters, the Korean medical officers were holding a meeting where this consultant spoke on the care of battle casualties involving bones and joints.

A very important duty which our medical officers have assumed is the training of Republic of Korea medical officers and civilian doctors. Korean medical schools have been badly disorganized by the War. Many of our medical officers are acting as teachers in these Korean medical schools. In the United States Army hospitals situated in the Korean Communications Zone, some forty-seven six-month residencies have been instituted for medical officers of the Republic of Korea Army.

The Korean Medical Field Service School is, on paper, a replica of our United States Army Medical Field Service School. The training required for Korean civilian nurses is two years. It is interesting to note that English is now required for all Japanese and Korean schools of every sort.

From the Ninth Corps, Col. Davis took us to the 46th and 44th Army Surgical Hospitals and then to the 121st Evacuation Hospital.

United States Army Medical Corps Procedure in the Far East

The holding policy for the wounded in the Far East Command is exactly analogous to that in the European Theater in World War II, so it is easy to follow. Any United States casualty who cannot be returned to duty within a period of 120 days is returned to the Zone of the Interior at a time appropriate to the wound or injury sustained and the reparative treatment required. The evacuation from the Army area to the Zone of Communications is as prompt as possible. Only the seriously wounded, such as men with abdominal or chest wounds, or those who have had arterial repairs, are retained in the small Army surgical hospitals until evacuation will not endanger life or limb.

Those wounded who might return to duty within thirty days are evacuated to the Korean Communications Zone, as are all Korean casualties. Those wounded who require a longer convalescence or those who will certainly be returned to the Zone of the Interior are evacuated to Japan. A fairly sizable number of United Nations casualties other than United States troops are returned to our hospitals in Japan for reparative and also definitive surgical treatment.

I was assured that the load of casualties at the time of my visit was light but, nevertheless, I saw approximately 600 United States casualties on the orthopaedic services in our Communications Zone hospitals; approximately thirty of them, rather seriously wounded, were in two small sixty-bed Army surgical hospitals. In addition, one hospital visited held approximately 300 wounded of the Korean Service Corps and Far East Liaison Detachment. One prisoner-of-war enclosure visited held some sixty-five casualties with orthopaedic wounds.

Just as we reached Korea, there was sharp action at the front which resulted in a considerable number of casualties. A few days later another local action again resulted in the arrival of a number of serious casualties at the Army surgical hospital which I was visiting at the time.

The majority of the wounds which I saw were due to mortar fire and many were multiple. Under ordinary circumstances, of the wounded who survive to reach hospitals, 70 to 75 per cent. have wounds of the extremities. The use of the body armor has changed this ratio by reducing the number of abdominal and chest wounds, so that extremity wounds may total approximately 90 per cent. The soldiers are very ready and anxious to wear the vest, which protects them against any missile with a velocity below 1,300 feet per second.

The over-all mortality among the wounded arriving at hospitals in the theater is said to be from 1.9 to 2.5 per cent. This is a distinct improvement over that in World War II. There are definitely acknowledged reasons for this, as follows:

1. The surgical principles found to be sound in World War II have been meticulously followed from the time some semblance of order was established, within a month or two after the War began.

2. The front is now stabilized and the confusion of surging battle lines and moving hospitals does not exist.

3. There is rapid evacuation by helicopter of the seriously wounded, allowing an average time of two to three hours between wounding and resuscitation with initial surgical treatment. There are, of course, tragic exceptions to this when the tactical situation will not allow rescue of the wounded. The helicopter will bring the wounded from the battalion aid station to the surgical hospital in a matter of fifteen to twenty minutes, whereas an ambulance ride between the same points would consume up to three hours over very rough roads. One has to ride in a helicopter to appreciate what it means in the rapid evacuation of our

wounded. Control of the air is presumably essential to the use of this type of transport, and on occasions its flight is prevented by weather.

A surgical research team is studying the response of the body to severe injury through the complete records on 500 seriously wounded, selected from some 4,500 wounded who have passed through the Army surgical hospital where the research team is stationed. The results of these studies on trauma, if disseminated to all medical officers, are certain to improve the care of the wounded.

The Army surgical hospital is now a sixty-bed hospital, whereas formerly it had 200 beds. Medical patients are rarely sent there, being evacuated to the rear. Only the seriously wounded, with abdominal and chest wounds, and those requiring arterial repair are kept non-evacuable at this level for over a day or so. The men who have had arterial repairs are kept for ten days.

The personnel of each of these sixty-bed hospitals consists of approximately fourteen medical officers, fourteen nurses (including two anaesthetists), and ninety-nine enlisted men. At the time of our arrival at the 46th Army Surgical Hospital, under the command of Lt. Col. George Hayes, there were only eight patients. Four casualties were admitted during the night and six more the next afternoon. All of these arrived in good condition. All of the last six had been wounded by mortar fire. Four had been evacuated by helicopter from the battalion aid station, arriving two and one-quarter hours after being wounded. The average time of arrival is said to be about three and one-half hours after the wound was sustained.

In all hospitals visited, the peak load of battle casualties in the past year was reached in October 1952. In March 1953 the load was said to have been very light. At the 46th Army Hospital in January 1953, there were 277 patients requiring operative surgery. A high percentage of these had fractures. There were fourteen with battle wounds of the chest and twenty-eight with wounds of the trunk. Seven peripheral-nerve lesions were noted, and six vascular lesions,—three brachial, two popliteal, and one femoral artery—which were repaired by anastomosis, suture, or vein graft.

At this 46th Army Hospital I had the opportunity to spend part of an evening with Capt. John Howard, who is head of the research team. His successor, Maj. Curtis Artz, was also there. The problem under study is the response of the human body to injury. These studies will be fully reported in time. Here are a few of Capt. Howard's observations.

Irreversible shock in the absence of continued hemorrhage and wounds of the central nervous system is never seen before anaesthesia. The amount of blood required to resuscitate a wounded soldier is a good indication of the possibility of successful resuscitation. Patients with abdominal wounds and zero blood pressure who require over fifteen pints of blood will show 100 per cent. mortality, while of those with wounds in the extremities the mortality is only 12.5 per cent. Renal failure is much less apt to occur in patients with extremity wounds. Capt. Howard told of three patients, each of whom had received forty-two pints of blood in twenty-four hours, with two surviving.

Morphine, demerol, and sodium pentothal should be used sparingly and with caution. The syrettes of 0.5 grain (32.5 milligrams) of morphine constitute an overdose in many instances. Many patients with wounds of soft tissue have little or no pain and require no sedative.

Fat embolism is not a frequent or important complication of wounding.

Gas Gangrene: During eighteen months with 4,500 wounded under observation, Capt. Howard has seen only six cases of this complication, with but one death which occurred in a patient who also had renal failure.

Arterial Anastomosis or Suture: This attempt to salvage an avascular extremity is extremely interesting and rewarding. It is a meticulous, time-consuming technical procedure requiring two to three hours. Lt. Col. Carl Hughes who is, I believe, correlating the results, has done thirty-six of these repairs with five failures, while over 300 have been done in the theater. Capt. Howard observed that the failures increase rapidly if over ten hours elapse between wounding and repair of the vessel. These patients are kept under observation for ten days in the hospital where the repair is done. The success of these operative procedures was said to be as high as 83 per cent. and even higher in the Army area. Not all the apparent successes in the Army area remain in that status in hospitals in Japan. The real test of this type of surgery lies in popliteal-artery repairs. If 50 to 70 per cent. of those with such wounds escape amputation, it will mean another surgical achievement of great significance. It was noted that in the hospitals in Japan, popliteal-artery repairs with severe compound fractures of the femur showed a significant increase in failures, perhaps 50 per cent. Failure in one or two instances was due to infection, apparently from an originally incomplete débridement. The surgeons doing these arterial repairs cannot afford to neglect the other damaged soft tissues.

At the 44th Army Hospital there had been forty-nine admissions on the previous day, forty-four of which were battle casualties, including six with abdominal wounds, one neurosurgical patient, and twenty to thirty patients with compound fractures. Ten of these patients were seriously wounded. Forty-two operations had been performed. Some of these men had been trapped in an outpost and had not arrived until eight hours after being wounded. In the action from which these wounded came there were approximately seventy-seven wounded and seventeen killed. The ten seriously wounded were equally divided between South Korean and United States troops. Most of them had multiple wounds. One soldier with a traumatic amputation of the left leg, an abdominal wound, and a compound fracture of the right humerus died

twenty-four hours after operation with zero blood pressure. The others who were severely wounded were expected to survive. The surgical care given these wounded was superior. The circular plaster-of-Paris splints applied in this Army hospital were properly split or divided prior to evacuation of the patient. This is the only safe way to evacuate a patient with a recent compound fracture.

Lt. Col. M. H. Pearson, Commanding Officer of the 44th Army Hospital, said that the monthly admissions to the hospital average 600, of whom approximately 420 require surgery. There are monthly averages of 150 compound fractures of the long bones, eight to ten arterial repairs, and sixteen major amputations.

The morning census in this hospital was forty-six and the afternoon census was twenty; this is an index of the rapidity of evacuation of the slightly wounded or sick.

While at this hospital, I visited the First and Third Battalion Aid Stations of the Seventh Infantry Regiment, Third Division. These were well organized and well supplied with splints and all medical supplies. Each aid station has three litter-jeeps, each of which carries two wounded on litters. There is occasional need for whole blood at the aid station, and the battalion surgeon may have to go forward to the advance station to administer it as an emergency life-saving procedure. I learned that this blood must be obtained from the clearing station on demand because the aid station has no storage facilities. Both of these aid stations were in well constructed bunkers in the lee of a steep hill. We reached them by helicopter, which is the means of evacuating the seriously wounded.

We went by plane from the 44th Army Hospital to the 121st Evacuation Hospital. Through this hospital went all the American and other United Nations returned prisoners of war, except Korean, a total of 188 at this time. The Chief of Medical Service, Capt. Donald Fusia, who had seen all of them, made the following observations:

1. The commonest disability was the extremity wound with compound fracture. Very few of these patients had had original wound surgery such as that which we now consider basic. Fifteen to eighteen patients showed persisting bone infection. Later in the Tokyo Army Hospital, no instance was noted of a compound fracture of the femur. Those with this common war injury either failed to survive or returned as amputees.

2. There were twelve cases of pulmonary tuberculosis diagnosed by roentgenogram.

3. All of the returned prisoners were considered to be undernourished. There were none who had not lost weight, some of them 25 to 40 per cent. of their body weight. Feeding varied in different prisoner-of-war camps, and the situation improved somewhat early in 1951.

4. There were a good many peripheral-nerve injuries among the wounded returned.

5. One returned officer stated that there had been six American medical officers at his camp but they had not been allowed to treat our soldiers. Treatment was carried out by Chinese doctors, whose professional skill, in the opinion of the returned officer, was about at the level of that of our enlisted medical personnel.

6. All of the returned prisoners of war had had dysentery at some time.

7. The returnees felt that some of their number may have been converted to Communism. This matter of indoctrination of our prisoner-of-war personnel was originally considered top secret, but within one week it was spread through the daily and weekly press, so that even a surgical consultant might mention it casually.

The only two remaining returned prisoners of war were a very sick diabetic and a man with advanced pulmonary tuberculosis. The soldier with diabetes was a Second Division Infantry man, who came in at Inchon and was captured at the Yalu River. He lived mostly on potatoes and rice. He said that of the original group of 3,000 who were captured, only 1,200 survived the march. He had not received insulin, although he had been told by the Chinese doctor that it had been ordered. This soldier had a blood sugar of 300 on arrival at this Hospital. The soldier with advanced pulmonary tuberculosis was also from the Second Division. He said he had lived on sorghum and beans for one and one-half years, and then finally he had received a little pork. He had been sick for ten months and had been kept in bed, because the Chinese were afraid of contagion. He is said to have received fifty to sixty doses of streptomycin.

The 121st Evacuation Hospital had 345 patients at this time, and three quarters of these were surgical. There were very few orthopaedic casualties at the time. The holding time at this point is only five to ten days. There is a great deal of the station-hospital type of work, predominately knee and back disabilities. These were discussed freely with the orthopaedic staff. In time of stress in the forward hospitals, many of the wounded are evacuated to this Hospital for initial surgery. A considerable number of arterial repairs have been done here.

Korean Communications Zone

In the Korean Communications Zone, we visited the 21st and 25th Station Hospitals, the 171st Station, the 14th Field Hospital, and the Republic of Korea prosthetic-appliance shop.

The 21st and 25th Station Hospitals at Pusan and Taegu, respectively, treat United States Army personnel, for the most part, mainly the wounded and injured who it is hoped will be returned to duty. In both these hospitals there are clinics where knee and back disabilities are reviewed. A recent severe action at the front (Pork Chop Hill) had resulted in a good many battle casualties being admitted to the two hospitals. Due to the fact that the 121st Evacuation Hospital had to be cleared to receive the repatriated prisoners of war, a good many of the wounded either by-passed this hospital or were evacuated from it into the Korean

Communications Zone Hospitals. Over 50 per cent. of the patients in these Korean Zone Hospitals are returned to duty within the thirty-day holding period.

One of these two hospitals reported that in 1952, 2,311 battle casualties were received. Eighty-six per cent. of the wounds were caused by shell fragments; only 7 per cent. were due to small arms fire; 7 per cent. were miscellaneous wounds including burns. The patients in the Korean Communications Zone were intelligently handled and the personnel assigned to their treatment seemed well informed and able to handle their problems. Occasionally they have had to do emergency surgery which would normally be done in the Army area. Wounded who have had to be sent back to the Korean Communications Zone for débridement, although late from the standpoint of optimum results, have done well. Even though as long as thirty-six hours has elapsed after wounding, at one of these hospitals only one case of gas bacillus infection was noted in five months, among 470 wounded. This patient recovered with an adequate second débridement.

Hospitals in the Japan Zone of Communications

In Japan, this consultant visited all of the Army hospitals which were handling battle casualties, a Naval hospital, and one Air Force hospital. These Army hospitals were the Tokyo Army Hospital, the Yokohama Army Hospital, the 343rd General Hospital, all in the Tokyo Area; the 279th General Hospital, the 382nd General Hospital, and the Osaka Army Hospital, in the Osaka area; in the Fukuoka area, the Army Hospital Unit 8162 United States Army Hospital Fukuoka, and finally the 141st General Hospital, Hakota.

At the time of this visit, from a medical standpoint, the War was surgical. Surgical admissions and census on the surgical wards far exceeded medical. This situation reflects great credit on the Medical Corps of the Army for minimizing sickness and preventing epidemic disease in a terrain where human excreta abounds, and for thus maintaining the fighting strength of our troops.

The orthopaedic census at these Army hospitals varied from twenty to 300 patients with an average of 126 per hospital. In most instances every patient was seen. This entailed extensive ward rounds and a good deal of discussion with the medical officers in charge. Battle casualties on these orthopaedic services were 30 to 90 per cent. of the total number of patients.

Closure of wounds by suture or skin graft was almost universally satisfactory. In a few instances both Col. Bolibaugh and I felt that too much time had been allowed to elapse before closure was attempted. The officers who did the closures at this level felt that for the most part the primary surgery at the Army hospitals was well done. Exceptions to the rule, of course, occurred, especially when inexperienced replacements took the job over from officers who were rotated home. It was said that in most instances at the time of closure of the wound, it was necessary to do a secondary débridement. One chief of an orthopaedic section stated that 70 to 80 per cent. of the closures of wounds over compound fractures were successful on the first attempt. The compound fractures which posed the greatest problem in closure were those of the distal portion of the tibia, where, in some instances, it seemed almost impossible to cover the exposed bone except by pedicle grafts. Several of those seen will probably come to amputation.

Wounds Involving Joints: It was particularly striking to see how routinely these wounds, which are most numerous at the knee, had been treated by an adequate early débridement with closure of the capsule. The delayed primary closure of the skin was done in these hospitals and early motion was started.

Skeletal traction was always used initially in the immobilization of compound fractures of the femur, and was very effectively employed. It was occasionally utilized for compound fractures of other long bones. In some instances, skeletal traction through the first metacarpal bone was employed successfully in compound fractures of the forearm.

Intramedullary Fixation of Compound Fractures: This procedure was outside of our experience in World War II, and I must say that I approached it with some skepticism. I am frank to admit that, after seeing a good many cases in which it was employed, I believe it is a valuable method of treatment if it is intelligently used, and it is being so used at present in the Far East.

Intramedullary fixation is utilized for the femur, only occasionally for the tibia, and at times for the humerus and for forearm fractures. In the great majority of instances it is employed after the wounds have been closed and healed. One chief of orthopaedic service, Col. Jeffress at the Tokyo Army Hospital, had inserted the intramedullary nail in forty compound fractures of the femur after healing of the wound, and in four fractures prior to healing. Comdr. Friend, United States Navy, at the Yokosuka Hospital had utilized the intramedullary nail in thirty-eight or thirty-nine compound fractures of the femur, in many instances before healing of the wound. Wound infection or "abscesses" developed in six instances but, with incision, healing supervened. In most instances these intramedullary fixations were done after wound healing and results in the patients seen were extremely satisfactory. Several soldiers and a sailor were walking, bearing weight with crutches, one month after each had been treated by insertion of an intramedullary nail into a femur shattered by gunshot. The alignment of the fractured fragments was excellent and callus formation was rapid.

Amputations: The amputees returned to the hospitals in the Japan Zone of Communications almost invariably had had the circular type of amputation with adequate skin traction during evacuation; this traction

was continued in the hospitals. If the initial amputation has been done by personnel other than that of the United States, it may be returned closed at an elective site. This happens very infrequently and has not, I believe, been disastrous. The United States Army amputees are promptly returned to the Zone of the Interior with continued skin traction. The United Nations wounded, other than Korean and United States Army personnel, who are admitted to the Tokyo Army Hospital have re-amputation at elective sites and, if possible, prostheses are obtained. I was told that a Symes prosthesis could be produced by a Japanese bracemaker for thirty-five dollars, and a below-the-knee or above-the-knee prosthesis for seventy-five dollars.

Frostbite: Although I saw no cases of frostbite on this visit, I had seen many of them returned from this theater to the Zone of the Interior in 1950 and 1951. The incidence had dramatically declined as follows:

June 1950 to 1951–5,000
June 1951 to 1952–1,000
June 1952 to 1953– 250

Those cases occurring in 1952–1953 were much less severe. Most of the serious frostbites that this consultant has seen in the Zone of the Interior occurred in the wounded with somewhat impaired circulation in an extremity, who lay out in the cold unavoidably or who had had to be transported long distances in the cold, also unavoidably.

Arterial Repairs: As was previously indicated, this is a truly great advance in wound surgery. Col. Zipperman of the 141st General Hospital stated that of 132 arterial repairs done in nine months of 1952, 77 per cent. were successful in Korea and Japan. Arterial repairs associated with compound fractures are seen on the orthopaedic service, and failure may occur in these severely wounded cases if jagged bone fragments erode the repaired artery. Since secondary hemorrhage is always to be feared and should be provided for, it is the feeling of this consultant that a tourniquet should always be at the bedside of such a patient. This practice was not invariably followed.

Disposition of Patients: One hospital in Japan reported the following disposition of 2,631 patients returned from Korea:

	No.	*Per cent.*
Returned to the Zone of the Interior by air	598	22 8
Returned to the Zone of the Interior by water	16	.6
Transferred to other hospitals	55	2 0
Returned to duty	868	33 0
Transferred to convalescent hospital, to return to duty later	1,094	41 6
	2,631	100 0

From this particular hospital only 23 per cent. of the patients were returned to the Zone of the Interior, while approximately 74.5 per cent. were returned to duty in the theater within the 120-day holding period.

In the Korean Communications Zone, at the 125th Station Hospital, this consultant was told that 50.4 per cent. of the surgical patients were returned to duty, while 49.6 per cent. were evacuated to Japan. This was accomplished presumably within the thirty-day holding period.

Korean Sick and Wounded

The United States Army Medical Corps has, as previously indicated, been instrumental in training Korean Army medical officers in administration of their Medical Department and in the care of the sick and wounded. In addition to this, our Army Medical Corps provides actual care for a considerable number of Korean battle casualties, injured, and sick among the Korean Service Corps, Korean troops with the United States Army, and the Far East Liaison Detachment. The 171st Station Hospital is practically limited to care of Korean personnel. There were 375 patients on the orthopaedic wards of this hospital. Ninety-five per cent. of these were battle casualties or injuries. I was told that an estimated 10 per cent. of Korean Army personnel had pulmonary tuberculosis and that the disease must therefore be much more prevalent in the civilian population. Among the wounded Koreans I saw six cases of tuberculosis of the spine, and I was told that they had recently had two cases of tuberculosis of the ankle joint and two of the hip joint. Since surgical care for these Koreans must be provided up to and including the definitive stage, arthrodeses were performed on spine, ankle, and hip. The care of battle casualties was of the definitive type, also,—elective amputations, bone grafts, and all sorts of reconstructive surgical procedures. This particular Hospital in the Korean Communications Zone requires well trained officer personnel and it affords an unusual opportunity to learn all phases of war surgery. The work observed was almost uniformly superior.

Prosthetic Appliances for Koreans

I visited the prosthetic-appliance shop near Pusan where a small United States Army medical detachment of one officer (Maj. John Butchkosky) and three enlisted men are supervising and training a sizable group of Korean enlisted men in the manufacturing of braces and prosthetic appliances. In a nine-month period they had made 1,200. There was, at the time of my visit, a backlog of 5,000 Korean amputees needing

prostheses. I was told that with Korean labor and United States supplies, prostheses were furnished at the following approximate cost:

Lower Extremity	*Upper Extremity*
Below-the-knee, $25.00	Below-the-elbow $ 85.00 (including Derrance hook and Becker hand)
Above-the-knee, $65.00–75.00	Above-the-elbow $100.00 (including Derrance hook and Becker hand)

Care of Battle Casualties and Injuries among Prisoners of War

I visited the 14th Field Hospital in Pusan where some of our wounded and sick prisoners of war are treated. Due to weather and the exchange of prisoners, we were unable to visit Koje.

At the 14th Field Hospital, there were approximately 130 orthopaedic patients. A considerable number had recently been repatriated. There were a considerable number of amputees. The incidence of infection in compound fractures is higher among these wounded prisoners of war because of the unavoidable delays between wounding, capture, and admission to the hospital. There were, at one time, 120 cases of tetanus among these prisoner-of-war wounded, but at the time of this visit there was none. There were some twenty cases of bone and joint tuberculosis. Ward rounds were made at this prisoner-of-war hospital. The few recent battle casualties seen had been well handled. Definitive reconstructive surgery is done on these wounded if they will submit to it. I was told that some "hard-core" Communists had refused to allow surgery to be done on themselves and that there were known instances where prisoners of war who had submitted to surgical treatment had been killed by their fellow-prisoners. Discipline among the prisoners of war at this time was said to be good.

Hawaii

I reached Honolulu on my return trip on May 6 at 7:30 in the evening and remained there approximately two weeks "at no expense to the government" according to my orders.

On May 9 I visited Tripler Army Hospital, under the command of Col. Thomas J. Hartford, where I gave a talk on the care of battle casualties involving bones and joints. This Hospital has a capacity of 1,500 beds and had a census at the time of this visit of 1,000 patients. There were 411 surgical patients, and of these, 184 were orthopaedic. The transient patients on their way home to the Zone of the Interior are seen by the orthopaedic surgeon only on a consultation basis. The battle casualties remaining there in the Hospital are those who live in the Territory of Hawaii. This Hospital is also used for the Veterans Administration of the Territory, which has the use of 185 beds, and the Public Health Service, which has fifty beds. This Hospital for transient casualties returned from the Far East has handled the following admissions:

1950, five months: 14,000, of whom 46 per cent. were battle casualties;
1951, first six months: 12,000 or more battle casualties;
1951, second six months: 10,000 or more battle casualties;
1952, entire year: 13,500 battle casualties;
1953, first five months: 1,000 per month battle casualties (approximately).

The personnel of this Hospital consists of sixty United States Army medical officers, 75 per cent. of whom belong to the Regular Army Medical Corps, and twelve Naval Medical Corps officers.

Ward rounds were made, and most of the problem cases were seen. There were two serious bone defects of the tibia seen and discussed with the Staff. Treatment was suggested and the prognosis in each case was guarded. Bone-grafting should be tried; amputation may be necessary. The treatment of orthopaedic patients in this Hospital is superior.

Summary

My visit was entirely devoted to observing the care of our United States Army wounded and of those of our allies who were cared for in our United States Army Hospitals. During this tour, complete ward rounds were made on the orthopaedic service or section in practically every hospital visited, and in each instance, there was informal discussion of the problems involved. Formal talks, illustrated with slides, on the treatment of battle casualties with wounds involving bones and joints were given at some twelve medical installations. On one occasion, at the 171st Station Hospital, where there were 710 Korean patients, I spoke on the treatment of bone and joint tuberculosis. At every hospital or medical installation we encountered courtesy and interest.

I was indeed proud to meet and associate with the medical officers, nurses, and other personnel of the Far East. It is not possible to acknowledge by name all the members of our medical department who are doing splendid work in that theater. Since I have spent over five years of my professional life in the service of the United States Army Medical Corps in two wars, it was a great satisfaction to see the smooth, efficient, and intelligent operation in the care of the sick and wounded of the Far East.

The few suggestions, such as earlier attempts to close wounds in some instances, and the provision of a tourniquet at the bedside of the arterial-repair patient, have been embodied in the report.

Proceedings

THE AMERICAN ORTHOPAEDIC ASSOCIATION

Annual Meeting, 1953

The Annual Meeting of The American Orthopaedic Association was held on June 29, 30, July 1, and 2 at The Homestead, Hot Springs, Virginia, under the presidency of Dr. James A. Dickson. The attendance was one of the largest, there being present about 400 orthopaedic surgeons and their wives. Among the many distinguished guests were Prof. Bryan McFarland of Liverpool and Prof. R. Merle d'Aubigné of Paris. It has been six years since the Association last met at Hot Springs—a welcome return to congenial and hospitable surroundings. The scientific program was excellent, the social activities seemed especially gay, and the meeting was an outstanding success.

The Scientific Sessions began on Monday afternoon, June 29, and were continued throughout the mornings of Tuesday and Wednesday, and part of Thursday morning. It is notable that the presentations at this meeting were, in the main, extremely well done. One cannot but remark, however, how few contributors to our national orthopaedic and other surgical programs present their work extemporaneously. When we find extemporaneous presentation, as at this meeting, it seems remarkable. Few of us speak without script; fewer still without notes. Most surgeons in this country read their papers and can do so with sufficient clarity and forcefulness to carry conviction. Yet the evidence is that the speaker who makes his contribution extemporaneously is far more effective and very much more considerate of his audience. When well done, extemporaneous speaking conveys a mark of distinction, although the price for the speaker in terms of mental anguish may be high.

Summaries of the papers presented at the Scientific Sessions follow.

Monday, June 29

Lateral Approaches to the Knee by Releasing the Lateral Ligaments from the Femoral Condyles. Dr. Otto E. Aufranc [1] presented a surgical approach to the knee which involves a release of the collateral ligaments. This he feels is helpful in order to visualize better the posterior portion of the meniscus and to facilitate its removal. In some instances, the postoperative convalescence was slightly prolonged. He had used the approach in cases of meniscal injury and loose bodies in the posterior compartment, especially in "tight" knees, for the past ten years and had become convinced of its superiority as an approach in his hands for these particular conditions. The ultimate stability of the knee is not jeopardized. He stressed the need for a careful repair of the ligaments and pointed out that a complete release is not always necessary. The general advantage of the approach is the possibility of extending the exposure when necessary by releasing the medial or lateral ligaments, provided that the incision has been properly placed in the beginning. It seems reasonable that this surgical approach would have a limited although definite use, particularly in patients in whom the posterior portion of the meniscus needs visualization and careful total removal. There is no doubt that the approaches are greatly widened by the activity of these ligaments as was convincingly shown in the moving picture presented.

In discussing the approach presented by Dr. Aufranc, Dr. H. Page Mauck [2] considered this a very satisfactory exposure in properly selected cases. Dr. Charles W. Peabody [3], however, emphasized the importance of a general utility incision to allow adequate exploration.

Stapling of the Vertebral Bodies in the Treatment of Scoliosis. Dr. Alan DeF. Smith [4], Dr. William H. von Lackum [5], and Dr. Robert Wylie [6] gave a preliminary report on three patients in whom they had stapled vertebral bodies to correct congenital scoliosis. This is a new approach to an old problem and was inspired by the principle of controlling growth in the epiphyses of long bones, as advocated by Blount. In the upper curves, the transthoracic approach is used; in the lumbar region, the approach is the same as that for the sympathetic ganglionectomy. Staples were placed into contiguous vertebral bodies so that compression on the disc and cartilaginous rings on the convex side of a spine curve resulted, thereby arresting growth. The arrest of growth on the convex side with continued growth on the concave side tends to correct the curve. They found this actually to happen over a period of three years inasmuch as deformity at the levels of stapling was arrested. Further experience will be necessary in order to answer the questions of when best to staple, how many levels to include, and how long arrest is necessary to correct completely a curve. At

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[3] 474 Fisher Building, Detroit 2, Michigan.
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[5] 654 Madison Avenue, New York 21, N. Y.
[6] 535 Park Avenue, New York 21, N. Y.

least for the present the authors have found the approach not too difficult and the convalescence more or less uneventful. The patients are out of the hospital in fifteen days without encumbering back supports. This is indeed a method of treatment which deserves further careful exploration. The authors employed the method in early severe congenital deformities, to which they feel it should be limited.

In discussion, Dr. I. William Nachlas [7] expressed the opinion that correction may occur with normal growth and proper stapling. Dr. John Royal Moore [8] had reported three cases; he felt that control of the deformity by stapling still remains doubtful.

A Comparative Clinical Study of Autogenous and Frozen Homogenous Bone in Grafting Procedures. Col. Ernest A. Bray [9] reported results he had obtained in a comparative series of operative patients; in seventy-five patients he had employed autogenous grafts and in seventy-five patients he had used frozen homogenous grafts.

He had conducted the study over the past three years in order to augment the evidence with respect to the relative usefulness of these two types of grafts. The two series seem fairly comparable, but it is to be noted that half of the total were fresh fractures. The distribution of delayed union, non-union, and major arthrodeses was about even. Prompt healing was obtained in 84 per cent. in both series. Delayed union occurred in 8 per cent. of the patients in whom an autogenous graft had been used and in 9 per cent. of the patients in whom frozen homogenous grafts had been used. There was failure in 8 per cent. of those in whom autogenous grafts had been used and in 7 per cent. of those in whom frozen homogenous grafts had been used. Four of the six failures with autogenous grafts were due to infection or further injury. The author's conclusions from this well conducted study and careful analysis of results are those which are coming to be widely held from such studies as this. He finds the operation of a refrigerated bone bank simple, practical, and inexpensive. The incidence of postoperative infection in the use of either type is roughly the same, although the probability of wound contamination appears to be greater with preserved bone. There appears to be a higher incidence of success with autogenous grafts. In the successful cases the rate of healing was about the same in the use of either type. Fresh autogenous bone of good quality he feels is always preferable except possibly in those patients in whom infection is feared; in this case he prefers to use frozen homogenous bone because in infected patients the latter type of graft seemed to do better.

The Use of Intramedullary Fixation and Cancellous Grafts in Established Non-Union of the Femoral Shaft. Dr. Harry D. Morris [10] reported a series of ten patients with established non-union of the femur treated by intramedullary nailing and the application of cancellous autogenous bone chips. Postoperatively, plaster spica immobilization was used for six to eight weeks. In all patients, union in good position was obtained. In one patient, a two-inch defect was filled with cancellous bone, successfully eliminating the shortening. In another patient, there was a recurrence of previous infection with postoperative drainage from the wound at the site of fracture and from the trochanteric wound. Drainage ceased from the former wound at the end of three weeks and from the latter when the intramedullary nail was removed at the end of eleven months. This did not interfere with union. Five of the cases were presented in detail.

Fracture Healing after Fixation with Standard Plates, Contact Splints, and Medullary Nails. Dr. Fred C. Reynolds [11] and Dr. J. Albert Key [12] reported upon another phase of their investigation of bone healing and the role of the compression factor. In this study, forty adult dogs were used. In nineteen one femur was exposed and was divided transversely, and the fragments were fixed with a standard steel plate and screws; the opposite femur was osteotomized and fixed with a stainless-steel Eggers plate and six screws. In a second group of twenty-one dogs, similar femoral osteotomies were performed, one femur being fixed with an Eggers plate and the opposite femur by a Lottes intramedullary nail. No external fixation was used in any dog. Because of severe infection and death, only fifteen animals in each of the two groups were available for study.

No statistically significant conclusions could be reached. Infection or granulomatous reaction occurred at the fracture site in seventeen of the femora. In some the screws holding the plate pulled out, while in others the intramedullary nail furnished insufficient immobilization. The authors received the impression from this study that, in dogs, progress of union was about the same with the two plates, there being slight advantage in favor of the Eggers plate. When the results from the use of the Eggers plate were compared with those from the use of the intramedullary nail, union was found to occur more rapidly when the Eggers plate was used, except in those instances in which the nail furnished adequate fixation. In those few cases, union was more prompt than with the Eggers plate.

The authors concede that the conditions existing in such a study on the experimental animal may not be valid when applied to the human patient.

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TUESDAY, JUNE 20

Developmental Deformities of the Lower Extremities. DR. ROBERT A. KNIGHT [17] emphasized the importance of certain sleeping and sitting habits of the infant and child which may interfere with the normal developmental pattern of the lower extremities and may cause deformity. He discussed the usual spontaneous correction of tibial torsion and bow legs; but stressed that, when the deformity is not cosmetically or functionally acceptable, it should be actively treated and not left to chance or to "nature", for often "nature" falls short of satisfactory results.

The deforming factors which were discussed and illustrated included the prone and supine positions in sleep, too bulky diapers, and the hip-straddle position of the carried baby. Incorrect sitting and sleeping postures as the child gets older may deform feet, legs, and back.

Prevention consisted in the correction of faulty habits; treatment of these developmental deformities when severe by Denis Browne splints, together with torsional stretching exercises which he feels are beneficial at least psychologically, will suffice in the younger age groups. Surgery may be necessary in children six years of age and over.

Torsion of Legs in Small Children. DR. J. H. KITE [14] continued in the same vein with a paper describing torsion of the legs. He discussed both medial and lateral torsion, saying that medial torsion is either congenital or acquired and that it is usually accompanied by bow-leg and pigeon-toe. Lateral torsion is usually accompanied by knock-knee and flat-foot. A review of the etiology, signs and symptoms, differential diagnosis, prognosis, and treatment was presented.

As did Dr. Knight, Dr. Kite emphasized the role of posture in sleeping and sitting. Similarly, he advised treatment for definitely abnormal amounts of torsion rather than the taking of the chance that they would become corrected naturally. The forms of treatment depend on the type of torsion and its degree and include corrective sleeping and sitting postures, manipulation by the mother, shoe corrections, and, when necessary, braces.

Rigid Valgus Foot. Harris and Beath in 1948 pointed out that the clinical entity of talocalcaneal bridge, together with talonavicular bar, constitutes the commonest cause for the rigid flat-foot, formerly called the peroneal spastic flat-foot.

In his present report DR. R. I. HARRIS [18] called attention to a group of patients in whom the bridging or coalition falls short of a true bony fusion, and in whom there is instead an anomalous bony ridge or protuberance on the sustentaculum tali.

This ridge prevents inversion or varus of the foot as it impinges against the talus. Although the condition is roentgenographically impossible to demonstrate by the usual coalition roentgenograms previously described by him, these abnormal ridges can be suspected nonetheless. In patients presenting rigid flat-foot, the diagnosis is based on a history since infancy of stiffness of the foot, valgus position of the heel, prominence medially of the tarsus, lack of subtalar motion, and a roentgenogram showing osteo-arthritic lipping of the superior margin of the head of the talus and sometimes of the navicular.

Although Dr. Harris does not specifically so state, the term tarsal coalition covers all the symptoms of congenitally rigid flat-foot. The fusion may be between the calcaneus and the navicular, the talus and the calcaneus, or, less commonly, it may involve other tarsal bones. The coalition may be bony (complete) or cartilaginous or fibrous (incomplete). It is in the latter condition that the special coalition roentgenograms may be negative, but all other findings of the rigid flat-foot may be present.

Regarding treatment, Dr. Harris concluded that subtalar fusion alone or such fusion supplemented by talonavicular arthrodesis is adequate. Many orthopaedists, however, feel that if surgery is to be carried out, nothing short of triple arthrodesis should be done. Dr. Howorth brought this out in his discussion of Dr. Harris' paper.

The Correlation of Congenital Dorsiflexion of the Ankle with Developmental Deformities of the Foot. In a study of the feet of over 500 newborn babies, DR. C. F. FERCIOT [15] found a severe dorsiflexion contracture to be present at the ankle joints in approximately 5 per cent., a moderately severe contracture in 5 per cent., and a mild dorsiflexion contracture in 5 per cent. There was a tendency in the severe cases for the babies to sleep prone with the lower limbs in the frog-leg position in external rotation. Observations of some 200 infants during the first year of life indicate that the calcaneovalgus foot is the sequel of this congenital dorsiflexion contracture. There seemed to be no anomaly of structure in the foot bones of these newborn babies. As function and growth develop, marked improvement is the rule; yet there becomes manifest a strong tendency for these children to grow up with hypermobile flat-foot. Dr. Ferciot urged the recognition and correction of this deformity during the early months of life.

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In the discussion which followed the preceding papers, Dr. Steele F. Stewart [17] made an eloquent plea for conservatism in the treatment of developmental and acquired extremity deformities, saying, "Let nature take its course"; but he showed little in the way of proof that conservative treatment is best, especially in the more severe conditions described in the preceding papers.

Dr. M. Beckett Howorth [18], in his comments, was in agreement with most of the thoughts expressed, but hoped for a more accurate and scientific appraisal of the cause of so-called developmental and acquired deformities.

Tuberculosis of the Spine: An End-Result Study of the Effects of the Spine Fusion Operation in a Large Number of Patients. Dr. Halford Hallock [19] and Dr. James B. Jones [20] presented excellent follow-up studies in a series of 1,009 patients with tuberculosis of the spine treated by spine fusion, extending over a period of thirty-six years. The group included 116 patients who had been followed for an average of twenty-two years. The longest follow-up was forty-one years, the patient having had the fourth spine fusion performed by Dr. Russell Hibbs for tuberculosis. This operation was performed in 1912. Aside from this wealth of material and its historical significance, the report consisted almost exclusively of statistical data which at times became a little confusing. The report incorporated statistics which had been included in several reports on the earlier cases prior to 1931, and it gave a detailed report of 192 patients treated between 1931 and 1947. In this group, the ages varied between fifteen months and twenty-five years. Pseudarthrosis occurred in fifty patients and paraplegia developed in twenty-three patients at some time during the course of the disease. Of the 192 patients, thirty-nine are known to be dead; thirty-six of these died of tuberculosis or of some complication related to it. There was an inadequate follow-up on fifty-three patients. One hundred patients were still alive and have been followed from five to twenty-two years. The disease was arrested in ninety-five of these patients, but there was persistent failure of fusion in fourteen and persistent paraplegia in four.

The authors concluded that spine fusion is a safe and effective means of obtaining satisfactory results in a high percentage of patients with tuberculosis of the spine. In the entire group of 1,009 patients, there was an operative mortality of only 1.28 per cent. One may differ with some of the recommendations as to the technique of performing the operation and with the management of the complication of paraplegia, but the statistical study is presented in a factual manner.

The Surgical Management of Tuberculosis of the Hip. Dr. F. P. Dewar [21], Dr. R. I. Harris [15], and Dr. H. S. Coulthard [22], in this presentation, were able to draw upon a vast amount of clinical experience gathered over a period of twenty-one years in a single, well controlled hospital for tuberculous patients. In this period of twenty-one years, they encountered 139 patients with tuberculosis of the hip and their report was based upon the study of 136 of these patients. The average stay in the hospital was one year. They pointed out the fact that changes in the plan of therapy in recent years have altered considerably the usual time of hospitalization. The beneficial effects of antibiotic therapy were also stressed. In this series of 136 patients there were twenty-six deaths among the non-operative patients. Of the remaining 110 patients, arthrodesis of the hip was attempted in eighty-five patients while twenty-five patients were not operated upon. There were three postoperative deaths and in fifteen patients, re-arthrodesis of the hip was required.

Their results show that bony ankylosis occurred in sixty-five of the eighty-five patients in the operative group and in seven patients in the non-operative group. Fibrous ankylosis occurred in ten patients in the operative group and in seven patients in the non-operative group. Failure of ankylosis occurred in twenty-three patients in the operative group and in eleven patients of the non-operative group. Surprisingly enough, the actual follow-up statistics indicate that hips with fibrous ankylosis did as well as those with bony ankylosis. The authors go on to point out, however, that in this group only one patient was doing heavy work and living a normal unsheltered life. Arthrodesis, they conclude, represents the treatment of choice, and solid bony ankylosis is advisable.

After years of wide surgical experience, the authors have concluded that multiple tibial grafts are advisable. They advise placing these grafts under direct observation on the posteromedial and posterolateral aspects of the hip.

Dr. James A. Dickson's [23] thoughtful address on a subject of deep interest, "The Unsolved Fracture", appears as the leading article in this issue.

Epiphysiodesis for Early Slipping of the Upper Femoral Epiphysis. Dr. Clarence H. Heyman [24] and

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DR. CHARLES H. HERNDON [25], dissatisfied with the slow healing of slipping femoral epiphyses after conservative treatment, drilling, or insertion of the Smith-Petersen nail, reported having performed a type of epiphyseodesis on nineteen capital femoral epiphyses with resulting fusion of the head to the neck in an average time of 2.3 months. This method is similar to that described by Dr. Beckett Howorth: The anterior aspect of the neck is exposed by means of a Smith-Petersen incision; a block of bone measuring three centimeters long and one centimeter wide is removed from the anterior portion of the neck. A drill one centimeter in diameter is then inserted into the head across the epiphyseal plate, and a single cortical graft or numerous cancellous grafts from the ilium are placed so as to bridge the epiphyseal plate. The block of bone is replaced, the capsule is resutured, and traction is applied for a few days. The patients are ambulatory on crutches after ten days, but weight-bearing is not permitted before twelve weeks.

The great advantages of the method, in the opinion of the author, are the rapidity of the fusion and the excellence of the functional results. The paper was illustrated by convincing roentgenograms.

In the discussion which followed some doubt was expressed regarding the wisdom of such an extensive operative procedure when adequate results could be secured by simpler methods which did not involve an arthrotomy of the hip joint. The authors countered by referring to the displacement of the femoral head which sometimes occurs during the insertion of the triflanged nail, to the difficulty of placing pins accurately, to the long period of time necessary for union of the head to the neck to occur by other methods, and finally to the fact that in none of their patients had there been infection or any untoward results.

Fractures of the Neck of the Femur in Dogs. DR. E. BRUCE TOVEE [26] reported on experimental studies of the incidence of aseptic necrosis, non-union, or both, in fractures of the neck of the femur in dogs. One of the most worth-while of presentations, this paper must be read to be appreciated fully. It is planned to publish it in an early issue of *The Journal*.

Functional Results of Hip Arthroplasty with Inert Prostheses. PROF. MERLE D'AUBIGNÉ [27], the distinguished guest of the Association from France, presented the results of acrylic femoral-head replacement on 405 patients in a documentary film. His patients were considered in two categories: those operated upon recently who have been observed for one year, and those operated upon earlier who have been observed from two to four and one-half years. These patients were also divided, according to the underlying pathological changes present, into the following groups: those following trauma; those due to osteo-arthritis, congenital subluxation, congenital luxation, rheumatoid arthritis, and ankylosing arthritis; and finally, a miscellaneous group. The grading into *very good*, *good*, *medium*, *fair*, and *poor* was done on the basis of an arithmetical formula, already published by Prof. d'Aubigné in *The Journal of Bone and Joint Surgery* (34-B: 22–29, Feb. 1952), in which the criteria of pain, mobility of the joint, and ability to walk were assigned numerical values. The author also tried to evaluate the improvement brought about by the operation by a similar mathematical formula. During the first two or three years, he had used the Judet prosthesis exclusively; during the last year he had employed an intramedullary prosthesis with a longer neck, termed by him *prothèse cervico-capitale*. The latter device is similar to the Frederick R. Thompson prosthesis, but is made of acrylic reenforced with metal. He was led to modify the Judet prosthesis because of the numerous dislocations (fourteen out of seventy-six cases) which occurred with the Judet head, due to shortening of the neck. From the technical standpoint his results, therefore, must be considered according to the type of prosthesis used. Thus, in thirty-two patients with a short neck due to non-union following fracture or to aseptic necrosis, the results in a group of patients in whom the Judet prosthesis was inserted and who were followed for six months to one year were:

Very good	13 per cent.
Good	9 per cent.
Fair or medium	22 per cent.
Poor	56 per cent.

Whereas with the new cervico-capital prosthesis, results in seventeen patients were:

Very good	83 per cent.
Good	11 per cent.
Poor	6 per cent.

When the neck was long, the Judet head gave better results. In twenty-one patients, the results were:

Very good	38 per cent.
Good	34 per cent.
Medium or fair	22 per cent.
Poor	6 per cent.

This superiority of results by the use of the new prosthesis, Prof. d'Aubigné thinks, is due to the restoring of the normal mechanics of the hip.

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In the group of patients with osteo-arthritis he had used at first the Smith-Petersen approach, but during the last three years he had come to prefer the Gibson posterolateral incision with the division of the glutaeus medius and glutaeus minimus. He had been careful to correct anteversion either by osteotomy or by the angle of insertion of the prosthesis, and he stressed an exact fit of the prosthetic head into the acetabulum. Thanks to attention to these points in technique, there has been a marked improvement in his results. Thus in sixty patients operated upon during the period 1948 to 1950, at the end of one year, the improvement was rated:

Very great	17 per cent.
Great	28 per cent.
Medium	17 per cent.
Poor	38 per cent.

But in the period 1950 to 1952, in eighty-six patients the improvement was:

Very great	20 per cent.
Great	39 per cent.
Medium	30 per cent.
Poor	11 per cent.

In the study of late results, there was deterioration in about 24 per cent. due to breaking of the prosthesis, wearing away, or bone absorption; in 24 per cent. there was improvement, probably due to increased muscle development; and in the others, the condition remained the same as at the end of one year. Pain is most probably due to bone absorption and the consequent loosening of the prosthesis.

D'Aubigné concluded that, although the results were encouraging, 20 per cent. of the patients were not improved. These failures were due in part to degenerative conditions over which the surgeon had no control and in part due to technical errors which could be corrected by improvements in design of the prosthesis.

In the report the impression was given of great accuracy in evaluation of a new method to which the author has made such a notable contribution.

My Present Attitude to Osteo-Arthritis of the Hip. Prof. Bryan McFarland[28] discussed the subject broadly. Of the many excellent papers presented at the meeting, none was more enjoyed and none was presented with greater clarity than this frank, witty presentation of a difficult theme by one who combines a high order of surgical skill and sound orthopaedic background with a rare gift as a public speaker.

Prof. McFarland indicated the value of certain lines of treatment in the early stages of osteo-arthritis when disability and joint changes are slight; he dealt mainly with the patient who is seriously handicapped by either pain or stiffness for whom operative treatment has become justifiable and sometimes necessary. He felt that for each patient the treatment most appropriate to all of the features of his case should be selected with the same care as that used in the choosing of the precise instrument for a particular job.

In the young patient (under forty) with unilateral involvement, Prof. McFarland is a strong advocate of fusion. For patients above that age, he tries to retain motion by either osteotomy or arthroplasty. He reviewed a large number of translocation osteotomies performed by Mr. McMurray and was gratified to observe how well these patients walked—almost all of them were back at work. He stated frankly that he was not sure what had caused the improvement, since in one instance, in a patient with a particularly good functional result, the attempted translocation osteotomy had not been accomplished and the postoperative roentgenograms gave a picture nearly identical to that seen on the preoperative roentgenograms. He thought, perhaps, that the osteotomy divides certain osseous pain pathways. In most of the patients involved unilaterally some type of arthroplasty is indicated. His preference is for the Judet acrylic head. This he inserts through the Gibson approach, taking particular care to conserve the gluteal insertions by stripping them from the femur with the vastus lateralis. Often, the arthroplasty on one side is combined with a fusion of the opposite side.

If the condition which he calls "big joint ankylosing arthritis" is present, he prefers a resection-angulation operation similar to that described by Milch and Batchelor.

In closing, he expressed a dissatisfaction with and a warning against the complacent acceptance of any of the present methods of treatment of osteo-arthritis of the hip; he indicated the need for greater insight into the cause of pain in osteo-arthritis of the hip; and he advocated the searching for materials and methods more compatible with the natural behavior of living tissues.

Two and a Half Years' Experience with a Vitallium Intramedullary Hip Prosthesis. Dr. Frederick R. Thompson[29] presented a careful follow-up study. Although based on a smaller number of cases than the paper presented by Prof. d'Aubigné, Dr. Thompson's observations on thirty-five patients correspond closely to those of the noted French guest. He, too, showed an admirable objectivity in the analysis of his results. His prosthesis in many respects resembles the *prothèse cervico-capitale* of d'Aubigné, his percentage of good and poor results corresponds closely to that of the larger French series. Dr. Thompson prefers the anterior

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approach, and he is particularly careful not to detach the capsule from the acetabulum so as to avoid the danger of dislocation. He pointed out that the three main complications which one must try to avoid are infection, fracture, and dislocation. If infection occurs, the prosthesis should be removed and a Colonna operation performed. Fracture may occur when the stem of the prosthesis is inserted or while reduction of the prosthesis into the socket is attempted. This danger cannot be stressed too strongly. The surgeon should not attempt reduction unless tests show "that less than one centimeter of traction will be necessary to pull the dome of the prosthesis down to the proper level of insertion".

Of the thirty-five patients, two were infected, one had a fractured femoral shaft, and one had a progressive slow subluxation which required a shelf stabilization. (In another patient a slow subluxation developed which thus far has not required surgical correction.) Of the remaining thirty patients, twenty-eight are "satisfied with the relief of pain obtained", and of these twenty-five have complete relief.

The Treatment of Osteo-Arthritis of the Hip by Means of the Prosthesis Type of Arthroplasty. Dr. Edward L. Compere [30] presented his experience with but one type of osteo-arthritis—that in which arthroplasty is indicated. Although he has used the Vitallium mold of Smith-Petersen, he has secured better results with the replacement type of operation.

He selects the particular prosthesis which seems best suited to the individual patient—the Judet, the Eicher, the Moore, or the Thompson. Frequently he combines the operation with a fusion of the opposite hip or with tenotomy of the adductors and neurectomy of the obturator nerve. When inserting the prosthesis, he seeks to re-establish not only the normal angle of inclination (about 130 degrees) but an anteversion angle of 15 degrees. Six cases were listed to illustrate one or more lessons learned in replacement prosthesis surgery and management. In each excellent results were secured by the insertion of the suitable prosthesis. In one patient, mold arthroplasty had been performed on one side, and the Eicher prosthesis had been inserted on the other. Subsequently, fourteen months later, subcutaneous tenotomy of the adductors was performed because of restricted abduction. The patient, although seventy-nine years old, has been able to resume his insurance business, but has some pain and limp in the region of the hip prosthesis. In another patient, however, the cup arthroplasty was a failure; the Eicher prosthesis has given an excellent result. The author uses the Gibson approach, and allows his patients to begin walking with crutches on the tenth postoperative day. Although he stated that the acetabulum is invariably abnormal, he did not describe the method of acetabular reconstruction he employs.

Thursday, July 2

An Experimental Study of the Effects of Cortisone on the Healing Process and Tensile Strength of Tendons. Dr. R. N. Wrenn [31], Dr. J. L. Goldner [32], and Dr. J. E. Markee [33] reviewed the results of their study of the healing rate and strength of tendon repair in dogs treated with ten milligrams per kilogram of body weight. Their results revealed that the excessive formation of peritendinous fibrous tissue was inhibited in primary tendon suture, and that approximation of tendons was easier in delayed suture. Although the healing of the tendon sheath was delayed under cortisone therapy, end-to-end tendon healing was not prevented. Cortisone-treated tendons were 40 per cent. weaker than control tendons. The effect of gelfoam, gelfilm, and pyromen on tendon healing was briefly described; these appeared to have some of the inhibiting effect of cortisone on fibrous tissue.

The Use of Hydrocortisone Acetate (Compound F) in the Treatment of Common Orthopaedic Conditions. Dr. H. H. Young [34], Dr. L. E. Ward [35], and Dr. E. D. Henderson [36] presented an excellent summary of the present status of hydrocortisone acetate (compound F) in treatment. The local anti-inflammatory and antirheumatic effect of hydrocortisone acetate was evaluated in the clinical study of 241 patients who were given 690 local injections. Dosages, complications, and general effects were reviewed. In rheumatoid arthritis its use was indicated in those patients in whom only a few joints were involved and in those in whom safe dosages of cortisone and general measures had controlled all but a few joints affected by generalized disease. Its use was justified in those in whom flare-ups of the disease in a few joints previously controlled by treatment had occurred, and in those in whom the use of cortisone or corticotropin is contra-indicated. Compound F is felt to be a useful adjunct to treatment on the basis of 49 per cent. marked improvement, 35 per cent. moderate improvement, and 13 per cent. mild improvement in the patients studied. In osteo-arthritis, improvement was usually between one and eight days' duration; where relief extended for a longer period, other factors, such as relief from weight-bearing, were involved. In a limited number of patients with trau-

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matic arthritis, psoriatic arthritis, and gouty arthritis, favorable reactions were noted. The treatment of tennis elbow was discouraging. All in all, the best results were found in those patients in whom temporary relief was afforded to self-limiting conditions.

Sling Procedure Survey with Recommended Modified Technique to Eliminate Earlier Shortcomings. DR. ROBERT J. JOPLIN [37] and DR. THORNTON BROWN [38] presented a thorough-going objective survey of the end results of Dr. Joplin's operation for the relief of the splay-foot and bunion syndrome. The tendon of the long extensor of the fifth toe is used to bind the transverse metatarsal arch, to prevent spread, and to supplement the action of the transplanted tendon of the adductor hallucis. The muscle power of the adductor hallucis is made to activate the arch by the transference of its insertion from the base of the first phalanx of the great toe to the distal end of the first metatarsal. This transference is probably an important factor in the success of the method. Modifications in technique were emphasized. In order for one to perform the operation correctly, the proper instruments are required, and detailed care must be exercised as this is not a procedure for the uninitiated.

The statistical study was accurate and continued analyses will in time allow the selection of cases for which this procedure is best adapted. In 58 per cent., more narrow feet resulted; in 72 per cent. plantar calluses beneath the metacarpal heads were eliminated or diminished; in 81 per cent. foot comfort was achieved; and in 89 per cent. the patient's reaction was one of satisfaction.

Comparison of Congenital Defects Caused in Developing Chickens by Certain Teratogenic Agents with Those Induced by Insulin. DR. P. K. DURAISWAMI [39] presented an interesting report of his experimental work in the production of congenital abnormalities in chick embryos by the introduction into the fertile chicken egg of various substances including insulin, sulfonamide compounds, thallium salts, 3-acetylpyridine, lead salts, and cortisone. The introduction of these various substances into the fertile egg of the chicken produced certain specific types of congenital deformities. With photographs and microscopic sections he drew analogies to congenital deformities seen in human beings. Whether one may justifiably draw conclusions from the comparison of congenital deformities in man with phenocopies, or artificially produced congenital anomalies in chickens, may well be questioned. Geneticists have been working on this interesting problem for many years and are understandably fascinated with it. The problem is a large one and is being attacked by geneticists from many angles. Dr. Duraiswami's work may lead to valuable information in the prevention and treatment of congenital deformities in the future, but at the present time, one must hesitate to view this work in any other light than as additional interesting investigations.

On Monday evening, June 29, the President's Reception was held at which the following newly elected members were presented:

Dr. Sam W. Banks, Chicago, Illinois;
Dr. Donald W. Blanche, Los Angeles, California;
Dr. Mark B. Coventry, Rochester, Minnesota;
Dr. Joe B. Davis, Portland, Oregon;
Dr. Frederick P. Dewar, Toronto, Ontario, Canada;
Dr. Frederick L. Liebolt, New York, N. Y.;
Dr. John H. Moe, Minneapolis, Minnesota;
Dr. Robert Perlman, Cincinnati, Ohio;
Dr. John A. Reidy, Boston, Massachusetts;
Dr. Edwin R. Schottstaedt, San Francisco, California;
Dr. William J. Tobin, Washington, D. C.

Dr. Joseph E. Markee, Durham, North Carolina, was elected an Honorary Member.

Dr. Theodore Garofalides, Athens, Greece, Dr. Sven Kiaer, Copenhagen, Denmark, and Prof. Bryan McFarland, Liverpool, England, were made Corresponding Members.

Later on Monday evening there was presented "Movie Memories of The American Orthopaedic Association Meetings, 1947 to 1952". This was a kodachrome film taken by Dr. H. R. McCarroll in which he projected a panorama of old friends, stirring scenes, places of special interest, and various social activities at six annual meetings of The Association, much of the history of which is a significant part of the story of American orthopaedic surgery. It is hard to imagine an hour more solidly packed with rich memories called forth by the photographer's artistry and embellished with his running commentary.

The first scenes of the film took the company back to the Virginia Hot Springs meeting, June 27 to 30, 1947, held when Dr. LeRoy C. Abbott was president. A splendid scientific program, clear sunny days, and many delightful parties and dinners had combined to make the meeting a memorable one.

[37] 1180 Beacon Street, Brookline 46, Massachusetts.
[38] Massachusetts General Hospital, Boston, Massachusetts.
[39] Department of Orthopaedic Surgery, Johns Hopkins University, Baltimore, Maryland.

Next came old Quebec in Canada when The American Orthopaedic Association (under the presidency of Dr. Robert I. Harris), The British Orthopaedic Association, and (then newly formed) The Canadian Orthopaedic Association jointly held their annual meeting in 1948. Here in addition to pictures of many old friends were scenes of the majestic Château Frontenac, the Terrace, the quaint French quarter of the Citadel, the Plains of Abraham, the Falls of Montmorency, St. Anne's Shrine, and the broad expanse of the St. Lawrence.

Next to the Broadmoor, Colorado Springs, Colorado, with Dr. Ralph K. Ghormley presiding, where at the foot of magnificent Pike's Peak and the snow-clad Continental Divide a brilliant meeting was held, May 18 to 21, 1949.

Then to Virginia Beach where Dr. Robert W. Johnson presided at the 1950 meeting, May 23 to 26. Here again we were treated to pictures of a host of old friends, scenes of surpassing charm, and another never-to-be-forgotten meeting.

In the next year came an inimitable meeting at White Sulphur Springs, June 20 to 23, 1951, with Dr. James S. Speed presiding.

The final scenes of the film were taken at the Joint Meeting of the Orthopaedic Associations of the English-speaking world, held in London June 30, July 1 to 4, followed by scenes of provincial tours. Here Dr. McCarroll is at his best—the Thames, the Houses of Parliament, Westminster, London Bridge, the Tower, the Gates of the Old City, Buckingham Palace, Trafalgar Square, Piccadilly Circus, the Trooping of the Colors, St. Paul's, the Admiralty, Grosvenor Square Gardens, Hyde Park, Windsor Castle pass in striking array, interspersed freely with veritable host of friends, old and new, from America, the British Commonwealth, Latin America, the Philippine Islands, and from virtually every other country—vividly recalling a meeting which will long be remembered as one of the best ever.

On Tuesday evening there was presented "The American Orthopaedic Association Returns to London" a moving series of pictures of London scenes, June 30, July 1 to 4 and of the never-to-be-forgotten visits to provincial centers. This film was taken by Mr. Macmillan of E. & S. Livingstone and was presented by him to The American Orthopaedic Association. Comments by our esteemed guest, Prof. Bryan McFarland of Liverpool, added to the charm of the panorama of friends, associates, and memorable scenes of those exciting days which have left such a happy and lasting impression on our memories.

The golf tournament proved popular and highly successful, although the scores left something to be desired. The winners of the tournament were:

First Prize (net): Dr. Carlo S. Scuderi, Chicago, Illinois;
First Prize (gross): Dr. David Oliver, San Antonio, Texas;
Second Prize (net): Dr. Donald Slocum, Eugene, Oregon;
Second Prize (gross): Dr. Paul McMaster, Los Angeles, California;
Consolation: Dr. Leonidas Lantzounis, New York, N. Y.;
Dr. Paul Norton, Boston, Massachusetts.

At the Second Executive Session held on July 2, Dr. A. R. Shands, Jr., of Wilmington, Delaware, the President for the coming year, was inducted into office. The following officers and members of committees were elected:

Officers

President-Elect: J. Warren White, M.D., Honolulu, Hawaii;
Vice-President: Leo S. Lucas, M.D., Portland, Oregon;
Secretary: George O. Eaton, M.D., Baltimore, Maryland;
Treasurer: H. Page Mauck, M.D., Richmond, Virginia.

Committee Members

Membership Committee: Walter C. Graham, M.D., Santa Barbara, California;
Program Committee: George J. Garceau, M.D., Indianapolis, Indiana;
Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania;
Research Committee: Carroll B. Larson, Iowa City, Iowa.

Representatives on The American Board of Orthopaedic Surgery

William M. Roberts, M.D., Gastonia, North Carolina;
R. Beverly Raney, M.D., Chapel Hill, North Carolina.

Delegate to the American College of Surgeons

E. Bishop Mumford, M.D., Indianapolis, Indiana.

The next Annual Meeting of The American Orthopaedic Association will be held at the Mt. Washington Hotel, Bretton Woods, New Hampshire, June 6 to 9, 1954.

AMERICAN MEDICAL ASSOCIATION
SECTION ON ORTHOPAEDIC SURGERY

The Annual Meeting of the American Medical Association was held last June in New York City. The Section on Orthopaedic Surgery met on June 2, 3, and 4, under the Chairmanship of Dr. H. Relton McCarroll of St. Louis, Missouri. The Secretary was Dr. Frederick R. Thompson. The meeting was a great success.

The following are summaries of the papers presented at the three scientific sessions held during the mornings of the three-day meeting:

TUESDAY, JUNE 2

The Early Roentgenographic Signs of Perthes' Disease. DR. TOM OUTLAND [1] pointed out that an early sign of Perthes' disease not generally known is a hypoplasia of the affected half of the pelvis. This was first described by Sakhachiev. Dr. Outland noted the hypoplasia on the involved side as being a constant finding in his cases of Legg-Calvé-Perthes disease. In patients involved bilaterally, 15 per cent. of the cases in his series, it is believed that the less severely involved side is likewise underdeveloped. The various diagnostic criteria of Perthes' disease were reviewed. A simple method of measuring the underdeveloped pelvis was demonstrated. Two patients involved bilaterally, in whom one hip became involved later than the other, made it possible to demonstrate earlier diagnostic changes than would have been shown by previous methods.

The discussion by DR. CHARLES WEER GOFF [2] emphasized the deceleration of growth in patients with Perthes' disease and their late maturity.

Panastragalar Arthrodesis. DR. WALTER S. HUNT, JR. [3], and DR. HUGH A. THOMPSON [4] had used an operative procedure, originally described by Lochioir in 1911, consisting in the complete removal and replacement of the denuded talus in order to obtain a combined ankle fusion and triple arthrodesis. They presented thirty cases with an average follow-up of three years, the operation being done on children over eight years of age. The technique was described in detail, its technical ease was stressed, and the relatively few complications encountered in its use were reported. The authors realized that this would seem to be a formidable procedure to many surgeons but, in their hands, its use had been gratifying. The talus, in the follow-up roentgenograms, showed increased density, but no cystic areas of aseptic necrosis were seen. Nonunion was rare.

The discussors, DR. ROBERT L. PATTERSON [5] and DR. ROBERT J. JOPLIN [6], told of the complications encountered in large series of panarthrodeses in their respective hospitals.

The Treatment of Infection after the Insertion of an Intramedullary Nail. DR. J. ALBERT KEY [7], DR. FRED C. REYNOLDS [8], and DR. JAMES O. LOTTES [9] discussed approximately thirty patients in whom infection developed after the insertion of medullary nails for the treatment of fractures. A few of these were their own patients; the majority came to them for secondary treatment. They described the method of treatment—sequestrectomy, drainage, and immobilization—and attempted to establish the criteria for the removal of a nail after infection had supervened. They believe that it is desirable and usually advisable in all instances to leave the nail *in situ*, particularly at the onset of infection; but they recognized that in certain instances it is necessary to remove the nail if the infection cannot be controlled. Amputation was discussed.

In discussion, DR. DANA M. STREET [10] and DR. HUGH SMITH [11] re-emphasized the value of adequate drainage and sequestrectomy, but mentioned the possibility of leaving a large sequestrum to serve as an involucrum until new bone had bridged the bone gap.

The Effects of Extensive Radiation on the Healing of Fresh Fractures. COL. AUGUST W. SPITTLER [12], COL. JOSEPH W. BATCH [13], and CAPT. BEN A. RUTLEDGE [14] presented a study carried out on healthy rats to deter-

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[2] 30 Farmington Avenue, Hartford 5, Connecticut.
[3] 309 Hillsboro Street, Raleigh, North Carolina.
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[6] 1180 Beacon Street, Brookline 46, Massachusetts.
[7] 4952 Maryland Avenue, St. Louis 8, Missouri.
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[9] 4952 Maryland Avenue, St. Louis 8, Missouri.
[10] Kennedy Veterans Hospital, Memphis 15, Tennessee.
[11] 869 Madison Avenue, Memphis 3, Tennessee.
[12] Brooke Army Hospital, Fort Sam Houston, San Antonio, Texas.
[13] Walter Reed Army Hospital, Washington, D. C.
[14] Walter Reed Army Hospital, Washington, D. C.

mine whether extensive radiation in sublethal doses would greatly affect the healing time of a fresh fracture fixed by means of intramedullary fixation. They wished to determine the feasibility of intramedullary fixation of fractures in persons who might survive an atomic blast with its radiation effect. It was concluded that rats with fractures subjected to irradiation have a higher mortality than those subjected to irradiation alone. They showed that fractures fixed by means of intramedullary nails heal readily without undue delay, in spite of extensive irradiation, and that the complications due to the fixation are no higher in the irradiated rats than in those not irradiated. They do not know if roentgen irradiation is absolutely similar to the irradiation of an atomic bomb blast. They believe that the slight delay in bone healing encountered in the totally irradiated rats is due more to their general sickness than to the local effect of the rays. Irradiated fractures will heal in spite of local necrosis.

The Triceps Surae Syndrome in Cerebral Palsy. Dr. Lenox D. Baker[15] showed that in 741 patients with cerebral palsy seen in his clinic, 193 operative procedures were done on 118 patients, after conservative therapy had failed to help them further. In his paper he pointed out the findings that indicate or contraindicate various surgical procedures. His paper was well illustrated and documented; a short moving picture showed the operative procedure of dividing the tendinous origin of the calf muscle. He believes that this procedure is safer and gives better results than the lengthening of the calf muscle itself.

In the discussion, the relative merits of calcaneal tendon lengthening, of neurectomies, and of muscle-sliding lengthening were compared.

Dupuytren's Contracture of the Foot. Dr. Herbert E. Pedersen[16] and Dr. A. Jackson Day[17] demonstrated that the fibrous nodules in the plantar fascia of the foot, which may look microscopically like fibrosarcoma or fibroneurosarcoma, are benign and are a Dupuytren's fibroplasia of the plantar fascia. He showed six patients, five of whom had undergone surgical excision of the plantar fascia. He stressed the fact that the microscopic picture of the plantar lesion is entirely different from that existing in the palm and is frequently thought to be a fibrosarcoma of high malignancy. Amputation of the foot had thus been advised and had been done because of the sarcomatous appearance of the tumor mass and because of a lack of knowledge that it is benign. In early cases, the histological picture suggests fibroplasia following degenerative changes in the aponeurosis. Although these tumors recur locally, adequate excision of the whole plantar fascia with its tumor mass has been successful in preventing recurrence.

The discussion by Dr. Emanuel B. Kaplan[18] stressed the fact that the tumor occurs in the medial part of the central plantar fascia slip covering the flexor brevis muscle, and not in the medial or the lateral slip. It is rarely seen in conjunction with Dupuytren's contracture of the hand, and is best named "Dupuytren's contracture of the foot" in order to signify its benignity.

Dr. J. Vernon Luck[19] stated that small, painless nodules may be left *in situ* for years unless they increase in size or become painful. The painful ones have been treated by hydrocortone with the relief of pain. The fibrocellular tissue, involving the plantar fascia, unlike that in the hand, does not contract and cause flexion deformities of the joints.

Wednesday, June 3

Early Management of the Injured Hand. Dr. Joseph D. Godfrey[20] and Dr. William D. Dugan[21] discussed the injured hand from the standpoint of first aid and immediate repair. They described properly placed incisions, and the extension of lacerations in order to achieve adequate exposure. Reduction and fixation of fractures, together with adequate splinting in physiological functional positions, were demonstrated by lantern slides.

Spondylolisthesis. Dr. Paul C. Colonna[22] analyzed 200 consecutive cases of spondylolisthesis treated in the Department of Orthopaedic Surgery in the University of Pennsylvania during a ten-year period beginning in 1942. This interesting study emphasized the age-period disability, as well as the sex incidence, and demonstrated that 85 per cent. of these patients can be treated conservatively.

In the discussion, Dr. John R. Norcross[23] stated that there is a fundamental difference between spondylolisthesis with a defect in the pedicle and the pseudospondylolisthesis in which the pedicle is intact and fusion is not necessary. Dr. Frederic C. Bost[24] discussed the importance of a thorough search for the pain-

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[20] 17 North Street, Buffalo 2, New York.
[21] 221 Pierce Avenue, Hamburg, New York.
[22] 3400 Spruce Street, Philadelphia 4, Pennsylvania.
[23] 122 South Michigan Avenue, Chicago 3, Illinois.
[24] 384 Post Street, San Francisco 8, California.

producing factor if operation is done. He believes that fusion is still the operation of choice until the simple removal of the arch alone can be shown to be more effective.

Chairman's Address: Has a Solution for the Unsolved Fracture Been Found? Dr. H. Relton McCarroll [25] gave an interesting, rapid-fire, clear, and succinct address on the subject of the fractured neck of the femur. The various methods of handling non-union and aseptic necrosis were discussed. This excellent address will be published in the *Journal of the American Medical Association*.

Problems in Management of Fractures of the Shaft of the Tibia. Col. Milton S. Thompson [26] reviewed the results in approximately 400 fractures of the shaft of the tibia treated at Brooke Army Hospital in Fort Sam Houston, Texas. There was a decided trend toward the use of intramedullary fixation. End results were discussed from the viewpoint of time lost and permanent disability.

In the discussion by Comdr. John S. Thiemeyer [27], it was emphasized that the results at the Portsmouth U. S. Naval Hospital were quite similar to those the author described.

Flake Fracture of the Astragalus. Dr. Bruce J. Brewer [28] described a type of flake fracture of the talus (astragalus) which can be confused with an area of osteochondritis of the ankle. Several cases of this type of fracture were demonstrated by lantern slides. The fracture causes persistent pain, and many are not diagnosed in the beginning, due to inadequate roentgenograms. The removal of the flake is considered necessary, although it is believed that some flake fractures, particularly those in children, seem to heal spontaneously or by immobilization.

The discussion by Dr. Nicholas J. Giannestras [29] and Dr. William Green [30] stressed the advisability of conservative treatment in children. There was general agreement that a causal relationship existed between trauma and the development of the subsequent degenerative changes in the talus in the adult.

Thursday, June 4

A three-hour panel discussion was held on the question "Are Bone Sarcomata Curable?" with Bradley L. Coley [31] as Moderator. Four important features were brought out in this three-hour discussion:

1. If pain appears in what previously was supposed to be a long-standing benign tumor of bone, the suspicion of malignant transformation should be strongly entertained.

2. Any sudden increase in size in a tumor of bone previously benign should label the tumor malignant in spite of a negative biopsy report.

3. Any large and seemingly benign lesion must be considered potentially malignant, since innumerable examples have shown that these lesions become malignant.

4. The physician should remember that a negative report of biopsy which is at variance with a roentgenographic or clinical observation of obvious malignancy should be accepted with reservation and the tumor should be considered malignant; on the other hand benign-appearing roentgenographic or clinical findings should be made to give way to a pathologist's report of high-grade malignancy.

Osteosarcoma (Osteogenic Sarcoma). Dr. C. Howard Hatcher [32] demonstrated the usual clinical course, the roentgenographic appearance, and the pathological features of osteosarcoma which usually results in death in spite of seemingly adequate early treatment by amputation.

The panel were unanimous in their feeling that local excision had no place in the treatment of this lesion. They showed, however, some instances in which the patients with lesions believed to be osteogenic sarcoma had lived for long periods of time, some with visible metastases in the lungs. They had no explanation for their longevity, but felt that they did not represent the usual picture of osteogenic sarcoma. The consensus was that osteogenic sarcoma is a highly malignant bone tumor which offers the very limited possibility of a five-year survival rate, most patients dying within a year and a half after the onset of symptoms.

Fibrosarcoma. Dr. J. Vernon Luck [19] mentioned three types of fibrosarcomata: the parosteal, the periosteal, and the central. He felt that only the central type is a true fibrosarcoma of bone. The parosteal type arises in tissue near a bone and is usually of low-grade malignancy, but it may have invaded bone by the time one sees it. The treatment of this neoplasm is local resection and, if recurrences occur, further local resection. Similarly, the periosteal type, which arises from the deep layer of the periosteum, may yield a biopsy benign enough to warrant local excision, but if the report is of high-grade malignancy, amputation should be done. The central fibrosarcoma, however, is the only true fibrosarcoma of bone and the unanimous consent

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[27] U. S. Naval Hospital, Portsmouth, Virginia.
[28] 425 East Wisconsin Avenue, Milwaukee 3, Wisconsin.
[29] 811 Doctors Building, Cincinnati 2, Ohio.
[30] Children's Hospital, 300 Longwood Avenue, Boston, Massachusetts.
[31] 140 East 54th Street, New York 22, N. Y.
[32] 950 East 59th Street, Chicago, Illinois.

of the panel was to amputate at or above the proximal joint. This rule must be universally adopted in contradistinction to the treatment of osteosarcoma, when a high subtrochanteric amputation may be successful in some instances in which the osteogenic sarcoma occurs in the lower portion of the femur.

Dr. Luck urged that the surgeon doing the biopsy be the one who ultimately conducts the care of the patient through all subsequent surgical stages. He strongly advised that, at the time of biopsy, careful closure of all subcutaneous and fascial layers be performed with primary closure of the skin, in order to prevent fungation of the tumor. Hemostasis should be carefully attended to.

Dr. Murray M. Copeland [33] mentioned fibrosarcomata arising from the nerve sheath adjacent to bones and involving the bone. These had a very poor outlook, and in his series of eleven patients only two had survived.

Chondrosarcoma. Dr. Murray M. Copeland stated that chondrosarcomata can be considered to be either primary or secondary. Primary chondrosarcoma occurs in young people from ten to twenty-five years of age and arises inside the metaphysis without giving evidence of a pre-existing benign cartilaginous lesion. A chondrosarcoma consists of embryonal type of cartilage. The five-year survival rate is very low—about 15 per cent. Since mortality in patients with chondrosarcoma is similar to that in patients with osteosarcoma, chondrosarcoma should be treated by amputation at the joint above the lesion. When chondrosarcoma involves the chondral juncture (although it rarely does), it should be treated by radical local resection, and if it involves the pleura or pericardium, this too should be excised.

Secondary chondrosarcoma, in contradistinction to the primary, usually occurs in people over thirty years of age and arises from a pre-existing benign lesion, either an osteochondroma or a central chondroma. The lesion is composed of a more mature type of cartilage. Secondary chondrosarcoma may be treated when it is small in size by local excision. In patients with secondary chondrosarcoma there is a five-year survival rate of 30 per cent. Dr. Norman L. Higinbotham [34] mentioned that a five-year follow-up of secondary chondrosarcoma is not long enough, since Dr. Coley had had a patient with a lung metastasis fifteen years after the lesion had been treated by amputation. He felt that a benign chondroma ought to be completely removed surgically. Multiple osteochondroma may turn malignant; thus if a chondromatous area shows rapid growth, if it interferes with the function of a joint, or if it begins to pain or to increase in size, it should be considered potentially malignant and should be removed locally. Dr. Coley emphasized the fact that large, bulky, benign osteochondromata should be considered malignant even when the biopsy has been judged benign by the pathologist. A large iliac osteochondroma should be treated by a hemipelvectomy since it will ultimately become malignant—if it is not already so—and will cause the death of the patient.

Parosteal Osteoma. Dr. Murray M. Copeland reported that while parosteal osteoma usually occurs at the lower end of the femur, it can occur in the fibula or in other bones. It is a densely ossifying mass without a base or pedicle and seems to arise on the lower end of the shaft of a bone. It invades the cortex and, later, the adjacent soft tissue on the outside of the shaft, but does not tend to invade the medullary cavity. When it arises in the membranous bone of the cranium, it is characterized by osseous fibrous tissue. The neoplasm is progressive but slow; it later becomes malignant. Parosteal osteoma usually occurs in early adult or middle life and is usually seen in the lower end of the femur or in the popliteal space about the femoral condyles. Parosteal osteoma is frequently confused with myositis ossificans. There is an early increase in size. In the beginning, the appearance suggests a benign growth. On biopsy the central portion may show hyaline cartilage containing islands of bony tissue, but as the periphery is approached, the biopsy material shows a malignant fibrosarcoma type of spindle cell, with occasional osteoblasts and, in some, even osteogenic sarcoma cells in the stroma. It should be treated by local resection.

Dr. Coley agreed with classifying this tumor as a separate entity. Dr. C. Howard Hatcher [32] stated that he used to believe parosteal osteomata were instances of myositis ossificans which had finally become malignant. He called attention to the fact that the tumor may blend with the cortex and seem to invade it, but that actually it did not invade the medullary cavity. He believes amputation is better than resection. Dr. Laurence J. Ackerman [35] has seen such a tumor recur twenty-five years after resection. Some criticism of the name of this tumor was made, and it was noted that Jaffe called the tumor "juxtacortical low-grade osteosarcoma". Dr. Hatcher suggested the name "parosteal osteoid osteosarcoma" to denote the fact that, while it seems benign, it is malignant. Dr. Copeland mentioned a case which Dr. Coley reported in 1913, which in 1909 had looked like myositis ossificans. Biopsy was done to prove this. By 1912 the tumor area had become a hard bony mass, possessing nodules which seemed to invade the lower portion of the femur. The patient, a woman, later died with metastases to the vertebrae. Dr. Copeland said he has had seventeen patients with such a tumor, three of whom have been lost to follow-up. Five are known to be dead, but nine are living and well. The nine were treated as follows: One had had excision; two had had wide resection; and the remaining six had had amputation. He stated that he did not know how many times excision should be done before amputation is warranted.

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[35] St. Louis, Missouri.

Ewing's Sarcoma Differentiated from Reticulum-Cell Sarcoma. DR. NORMAN L. HIGINBOTHAM[24], in differentiating between the two clinical entities, first presented a patient who at the age of thirteen had had a Ewing's sarcoma in the upper end of the humerus and who had been treated with 6,000 roentgen units, together with Coley's toxins. The patient was alive and healthy sixteen years afterward. Dr. Higinbotham stated that Ewing's sarcoma is rarely seen in patients over twenty-five years of age and that it is essentially a disease of children, which is frequently confused with osteomyelitis. He showed slides of a second case, a fourteen-year-old girl with a Ewing's tumor in the upper portion of the femur. She had been given roentgen therapy before coming under his observation. At the time of biopsy, the tissue showed osteitis. A year later, however, with further progression, another biopsy showed Ewing's sarcoma and the patient died within the year. He felt, therefore, that biopsy should be done before any roentgen therapy is given. The biopsy wound should be carefully closed in layers to prevent fungation of the tumor. Aspiration biopsy is highly successful and the possible complications of open biopsy are avoided.

He then described reticulum-cell sarcoma which he stated is another entity. This disease occurs in people from twenty to fifty-five years of age and possesses different characteristics and symptoms. The onset is slow, the progress is slow, and it is often characterized by dull, aching pain for many months. The limb gradually becomes disabled and there is marked swelling and oedema, due to soft-parts invasion, although the roentgenograms may show a minimal degree of cortical destruction and involvement. The treatment, however, is the same as in Ewing's sarcoma—biopsy should be done first and then the area should be irradiated. Amputation should be done only in treatment of complications. Roentgenograms of a humerus were shown; in this patient, 4,000 roentgen units, together with Coley's toxins, were given in treatment of the neoplasm. He projected interesting survival-rate tables, justifying the division of his patients into those with Ewing's sarcoma and those with reticulum-cell sarcoma:

Ewing's sarcoma: 4.1 per cent., five-year survival.
Reticulum-cell sarcoma: 48.1 per cent., five-year survival;
33.3 per cent., ten-year survival.

Dr. Ackerman concurred in the opinion that these tumors should be placed in two separate categories, and stated that they can be differentiated microscopically. Dr. J. Vernon Luck asked why amputation should not be done. Dr. Higinbotham replied that at Memorial Hospital they had given up amputation as a treatment of the lesion because all tumors regressed after roentgen therapy. Since the disease is not a local disease and since roentgen therapy controls the local lesion, death occurs from metastases to the other bones or to the lungs.

Plasma-Cell Myeloma. DR. LAURENCE ACKERMAN stated that he did not believe there is such a thing as a single-focus myeloma, but that the disease is generalized. The primary cell is a plasma cell growing in the bone marrow, and it is differentiated from a chronic granulomatous condition because it grows in sheets of plasma cells without the presence of inflammatory cells or of chronic fibrous reaction. He stated that various tests, such as the Bence-Jones protein test, the calcium-level determinations, and the serum albumin-globulin ratio are usually normal in the beginning. The earliest evidence is given by a sternal-marrow biopsy. If the plasma cells show an increase over the normal of 1 to 5 per cent., the diagnosis is positive. He showed an interesting slide of a skull pitted with typical plasma-cell defects which had largely cleared and ossified following the use of urethane, only to become pitted and eroded again as the disease recurred, resulting in the ultimate death of the patient.

Dr. Coley stated that he had never before seen urethane clear up the eroded area in the skull. Urethane has been used for about three years. The theory of its action is unknown, except that it seems to depress mitoses in malignant lesions. It was first used in England in the treatment of prostatic carcinoma. Dr. Coley's practice at Memorial Hospital is to give one gram of urethane daily for three days and to increase the dose slowly to five grams a day, maintaining this dose until 150 grams have been given. The dose is then slowly reduced to one gram a day and maintained at this level for long periods of time. It is felt that the drug is successful in relieving local bone pain and in relieving some of the anaemia. In general all the panel believed that about three doses of 500 roentgen units each applied to the local lesion might prevent local pain and reduce the incidence of fracture. Dr. Luck stated that a patient of his died under urethane therapy, but no lesions attributable to urethane poisoning could be demonstrated at autopsy. Dr. Higinbotham stated that in three patients who had died at Memorial Hospital there had not been shown at careful autopsy any urethane damage to the kidney or liver. The consensus of the panel was that this tumor is always fatal, and treatment is only palliative.

The following officers were elected for the ensuing year:
Chairman: Charles N. Pease, M.D., Chicago, Illinois;
Vice-Chairman: Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania;
Secretary: Frederick R. Thompson, M.D., New York, N. Y.;
Representative to Scientific Exhibit: J. Vernon Luck, M.D., Los Angeles, California;
Delegate: Edward L. Compere, M.D., Chicago, Illinois.

W. EUGENE WOLCOTT

1885–1952

W. Eugene, one of the five children of Hattie Teal and Venning Dodge Wolcott, was born in Battle Creek, Iowa, on August 13, 1885. He attended the public schools of that town and completed his university preparatory studies at the Iowa City Academy. Entering the College of Medicine of the University of Iowa, he was graduated with the class of 1910. After five years of general practice in Merrill and Council Bluffs, Iowa, he chose orthopaedic surgery as a specialty, and in 1916 he procured an appointment to the House Staff of the Hospital for the Ruptured and Crippled, New York. There followed two years of orthopaedic military service in World War I. He then returned to Council Bluffs, but soon crossed the wide Missouri for four years of association with Dr. Lord and Dr. Schrock of Omaha.

In 1923 he moved to Des Moines, Iowa. After nineteen years of strenuous work in orthopaedic surgery there, he went to Green Bay, Wisconsin, in 1942 for two years of emergency service in World War II. When he resumed his duties in Des Moines he found that he could no longer stand the pace which he had set. He retired from practice and attempted to assume a life of leisure, but his inherent drive proved inexorable and at Warrenton and Charlottesville, in Virginia, he soon became involved in the responsibilities of two farms, and Out-Patient Department and research duties at the University of Virginia.

Dr. Wolcott was a Fellow of the American College of Surgeons and an active member of his local, state, and national medical societies, The American Orthopaedic Association, The American Academy of Orthopaedic Surgeons, and the Clinical Orthopaedic Society. He held staff appointments to the leading hospitals in the cities in which he practised, and he was active in many social and civic organizations, being particularly interested in the 4-H Clubs of farm boys and girls. He was a member of the Presbyterian Church. On August 3, 1920, he was married to Alice Houghton Becker. To them was born one son, William Eugene Wolcott, Jr.

W. Eugene was christened with an initial to which he was expected later to add a first name of his own choice, but in spite of legal difficulties and confusion he never did so, thus asserting the independence so characteristic throughout his lifetime. Gene was aggressive and impatient; and he was urged by an irresistible drive to accomplish to the greatest possible degree what seemed to him to be right. He was intolerant of carelessness, indolence, or indecision in himself, his friends, and colleagues. For such human frailties he knew no compromise and, in the Army as in civil life, believing that official status or military rank did not excuse them, he acted accordingly.

When the State of Iowa adopted its laws for the care of cripples, Gene fought for distribution of state patients among the various hospitals which were adequately staffed and equipped for their care, as opposed to their concentration at the University Hospitals, — state-wide distribution of patients supported by state-wide taxation, which would seem just. For this he was accused of selfishness, disloyalty to his alma mater, and even worse motives. He was deeply hurt by such criticism but, convinced in his conscience that he was right, he gave no ground.

In private practice Dr. Wolcott was unusually proficient, thorough, and meticulous. He left nothing to chance and little responsibility to others. Driving himself unmercifully, he established a following larger than he could care for, and had difficulty in finding associates who would, or could, maintain the pace that he set and demanded. Despite his grueling activity, he found time to demonstrate, as no one else had done, the circulation of blood to the head and neck of the femur during various ages of growth, from infancy to maturity.

Like all native Iowans, he was born with a great love for the land. Farming was his second nature. At Des Moines his farm was his escape from the press of professional life, and when his son entered a school for boys in Warrenton, Virginia, he purchased a farm near by, spending odd hours in the Out-Patient Department of the Medical School as assistant to his close friend Bob Funston, and pursuing research in orthopaedic surgery.

The gracious hospitality of the Wolcott home, perfect in appointment, friendly and warm in atmosphere, centered about son "Bill". This time the initial actually stood for a name. Visitors first met the charming hostess, then Bill, and, if circumstances were propitious, they toured the farm. In farming, too, nothing but the best was satisfactory, the best cows, the greatest production, the fullest restoration of worn land.

In the death of W. Eugene Wolcott, we have lost a beloved colleague; and we extend to the bereaved wife and son our sincere sympathy.

M. N. SMITH-PETERSEN

1886–1953

Early in June there came to a close the life of one of the great orthopaedic surgeons of the world, Dr. M. N. Smith-Petersen. All too soon he has passed away. Still leading an active life, in his sixty-seventh year, carrying a heavy operating schedule, consulting, teaching, speaking, writing, within the year he walked with a light springy step and seemed as deeply engrossed as ever in his friends and in his beloved orthopaedics. So powerfully was he sustained by his spirit of devotion to professional duty that it might never have occurred even to those close to him that for a number of years he was far from well. Yet one need not feel that he has gone; through his epoch-making professional contributions, his remarkable skill as a surgeon, because he was a gentle and good physician, and, not the least, through the depth of his capacity for friendship, he lives on, in spirit, in that select company of people whom the world will always remember.

PHOTOGRAPH BY BACHRACH

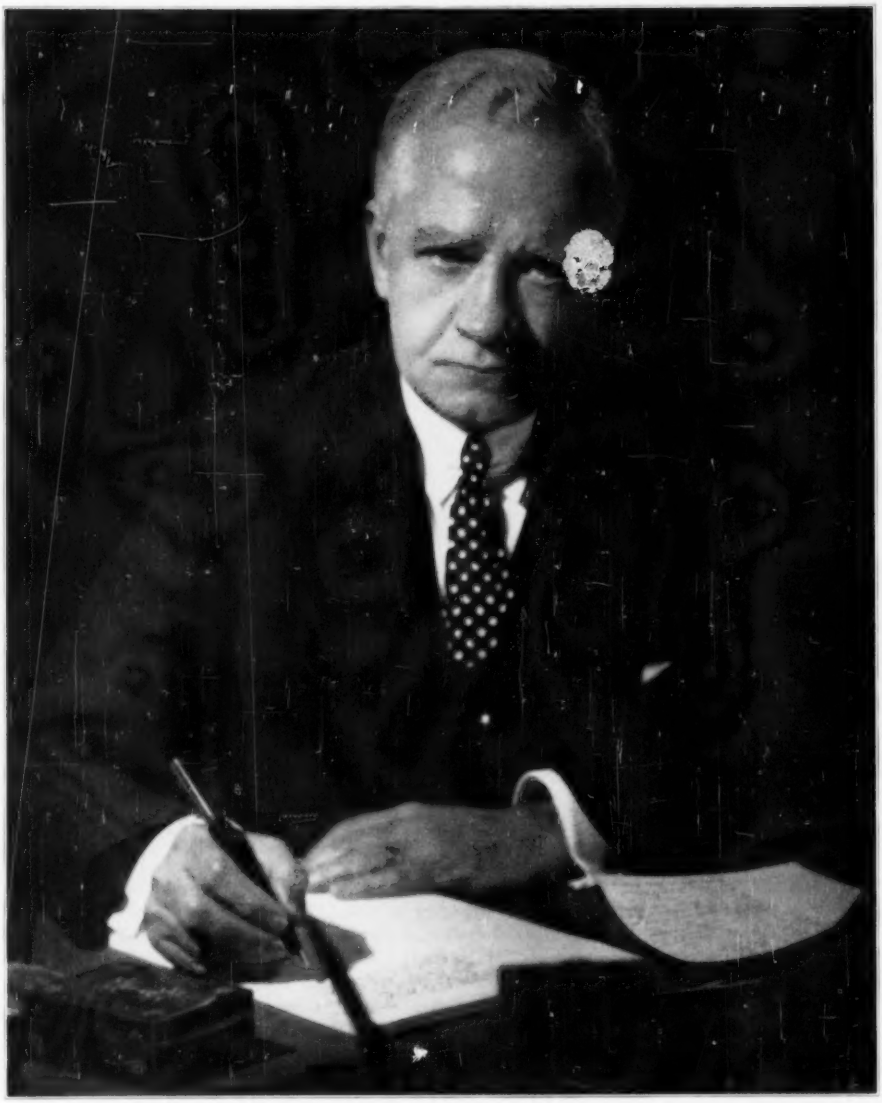
The subperiosteal approach to the hip joint (1917), his approach to and method of arthrodesing the sacro-iliac joint (1921), the effective internal fixation of the fractured neck of the femur (1931), the mold arthroplasty of the hip (1939), the surgical approach to the wrist joint (1940), and osteotomy of the spine (1945) are the works of a creative genius of the highest order. These contributions were, for the most part, revolutionary in their influence on the surgical technology of their day. To each he imparted a completeness in itself, each was a finished product, a work of art, a thing of beauty, and each represented a crowning achievement—the surmounting of a major surgical difficulty.

Dr. Smith-Petersen was a man of splendid vitality, drawing his energy from sources few in number but very deep. The love and inspiration which he gave and in turn received from a devoted family and a wide circle of friends at home and abroad gave his life balance. His tremendous capacity for work led to extraordinary accomplishments and in turn rich satisfactions. These rewards and his unquenchable love of orthopaedic surgery were the springs whence flowed his rich store of vital energy.

One of his most dominant characteristics was singleness of purpose. When he began his career as a physician, on graduating from the Harvard Medical School in 1914, he gave wholeheartedly an undivided professional allegiance that never wavered and never cooled till the day of his death. Unfailingly and gladly he subjected himself throughout his entire professional life to the exacting discipline that creative and top-level operative surgery demand. In the words of Dean Sperry, "What he asked of himself he asked of all who worked with him and lived with him—a like single-mindedness. They had to help him pay the price for the professional ideal which he had set before himself." Such single-mindedness as was his is reserved only for the great.

A former house officer, resident, and assistant of Dr. Smith-Petersen writes, "Uppermost in my mind is the personal magnetism that emanated from the grand old man. This magnetism had far-reaching effects, even down to influencing the results of his arthroplasties and to making those people around him work out their hearts and souls for him without any direct demand on his part. This quality, it seems to me, is one he may have been born with perhaps but nonetheless possessed, and had no small part in his ultimate greatness."

To some of his friends, there was something sad about "Pete" which seemed to come from a sense of his falling short of the goal he had set himself, and from a realization that he did not have power enough to fully satisfy his desire to be of service to his friends. There were occasions when he actually became the victim of groundless remorse from an overpowering sense of possible error in professional or moral judgment. He



would then seek out a trusted friend who he felt was competent to judge, tell him all, and, straightway, seemed to be relieved when it was pointed out convincingly he had actually made no error. It always troubled him that he possessed no hobbies. It seemed impossible for him to perform an act imperfectly; to do so was to him a violence against his nature.

In the art of conducting a clinic, there were few who were his equal. At his clinical demonstrations, case after case would be presented with such dramatic skill, force, and enthusiasm that visiting surgeons, house officers, students, and patients alike at once felt his outstanding ability. His diagnoses would be accepted as almost self-evident; one would be readily persuaded to his plan of treatment. The basis for this power lay not alone in his personal magnetism but also in the almost infinite care and pains he unsparingly took in making his diagnoses, in working out the details of his operations, in perfecting his skill and technique, and in the after-care. His last clinic was held in April, before the Robert Jones Club. It was a stirring demonstration by himself and his staff of a large group of patients upon whose hips he had performed, especially successfully, his Vitallium-mold arthroplasty. Throughout morning and afternoon he presented patient after patient

whose gratitude for relief from pain and for restored function knew no bounds. More brilliant results have yet to be shown. It was his last great teaching effort—a fitting memorial to thirty years of almost ceaseless labor and devotion directed toward the perfection of hip arthroplasty.

Had Dr. Smith-Petersen chosen law instead of medicine, he would have become equally famous. It was rare for him to testify in court; time did not permit. Only to protect a colleague who was being unjustly sued or wrongfully deprived of his due would he take the witness stand. When he did, however, his extraordinary forensic ability made him the object of the deepest respect of all present in the court. Overreaching attorneys soon learned to leave him strictly alone. Some years ago he flew over a thousand miles to testify on behalf of a fellow physician crippled in an automobile accident. His testimony won a handsome award for his friend. The case was appealed and again he testified. This time the award was doubled. Later, the case was once more appealed to a higher court and again he put aside everything else and fought for his friend. For the second time the award was doubled. The defendant paid; he had seen and heard enough of the Boston surgeon.

Marius Nygaard Smith-Petersen was born in Norway, November 1886, of a prominent old Grimstad family. In the windjammer days, his forbears were owners and operators of a great fleet of merchant vessels which called at ports the world over. Talented in music, patrons of the arts, cultivated, they knew the best life had to offer. In 1903, as a young student, unable to speak English, Smith-Petersen came with his mother to the United States. Here, partly on his own efforts and partly through the help of his mother who gave violin lessons, he was graduated from the West Side High School, Milwaukee, in 1906. Four years later he was graduated from the University of Wisconsin. There, in his senior year, he became President of the Cosmopolitan Club. Embarrassed in that office by his lack of knowledge of parliamentary law, he promptly mastered that procedure and ever after enjoyed a facility in it which few possess. His general surgical internship was served at the Peter Bent Brigham Hospital, Boston, under Dr. Harvey Cushing. Undoubtedly, that distinguished surgeon and scholar strongly influenced the young surgeon, combining, as he did, surgical boldness and radicalism with the most meticulous preparation, caution, and technical accuracy. Dr. Smith-Petersen's orthopaedic foundation was laid under Dr. E. G. Brackett at the Massachusetts General Hospital. There, after the day's hospital work (which usually was completed about ten p.m.) he and his fellow orthopaedic intern, Dr. LeRoy Abbott, would go to their room and until the wee sma' hours they would read *Whitman's Orthopaedic Surgery*. At the close of their service they had mastered this weighty tome. Although he had occasionally assisted Dr. Brackett in private practice before 1917, he formally became his office assistant on January 1 of that year. In October 1922 he went into practice for himself.

Dr. Smith-Petersen's career was, then, fully launched in 1922. Already, orthopaedically, his brilliant intellect had borne fruit. Disturbed by the frequent shock which followed hip surgery, due to exsanguination, while still a house officer, he developed the relatively bloodless supra-articular subperiosteal approach, which he published in 1917. Disappointed in the results he saw from fascia lata hip arthroplasty, he began in 1918 his work on mold arthroplasty, inspired by the perfect foreign-body cyst he exposed, which had formed around a piece of glass embedded in a boy's back. He did not publish the fruits of the years of his labor in the field of arthroplasty until 1939, for it was not until then that he felt the work was advanced far enough to justify publication. His fusion of the sacro-iliac joint had its genesis in a visiting surgeon's allowing him, when a house officer, to carry out his idea of removing an osteochondroma from the deep surface of the scapula through a window made in the external surface of that bone. The three-flanged nail occurred to his mind as he passed a sleepless night on the train. He had spent part of the previous day in an out-of-tov clinic, viewing the failures of treatment of fractures of the neck of the femur by external fixation.

Dr. Smith-Petersen, the friend and benefactor of mankind, lives on in spirit in his monumental contributions to surgery; in the hearts of a host of friends he still is with us.

Almost endless were his honors. Subjoined is the list of important positions he held and some of the honors bestowed on him during his active surgical career.

Assistant Instructor in Orthopaedic Surgery, Harvard Medical School, 1920–1930.
Instructor in Orthopaedic Surgery, Harvard Medical School, 1930–1935.
Clinical Professor of Orthopaedic Surgery, Harvard Medical School, 1935–1946.
Chief of Orthopaedic Service, Massachusetts General Hospital, 1929–1946.
Consultant to The Surgeon General, 1942–1945.

Member of:
The American Orthopaedic Association
The American Academy of Orthopaedic Surgeons (President of Academy, 1943)
International Society of Orthopaedic Surgeons
International College of Surgeons
International Academy of Medicine
World Medical Association
American College of Surgeons
American Medical Association

New England Surgical Society
Massachusetts Medical Society
Boston Surgical Society
Boston Orthopaedic Club

Honorary degree from University of Oslo, Norway, 1946
Honorary member of Norwegian Surgical Society, 1946
Grand Cross Royal Norwegian Order of St. Olaf, 1947
Honorary member of The British Orthopaedic Association, 1947
Honorary member of Société Française d'Orthopédie et de Traumatologie, 1948
Honorary member of Società Italiana di Ortopedia e Traumatologia, 1948
Honorary member of Royal Medical Society of Edinburgh, 1949
Honorary member of The Canadian Orthopaedic Association, 1949
Honorary fellow of Royal Society of Medicine, 1952

JOHN PATRICK MURPHY

1901–1953

While examining a patient in his office in St. Louis on March 25, 1953, Dr. Murphy died suddenly of a heart attack. He had not been well, and had worked only intermittently following an illness in June 1952.

He is survived by his widow, Virginia Jeep Murphy, whom he married in 1943, and three children, John Patrick, Timothy, and Terrence.

Born and educated in St. Louis, Dr. Murphy received his A.B. degree in 1924 and his M.D. in 1928, at St. Louis University. A year of rotating internship in St. Louis was followed by two years of surgical residency in San Francisco. His orthopaedic training was obtained at the Massachusetts General, Boston Children's, and Boston City Hospitals. He returned to St. Louis in 1935, entered private practice, and joined the Orthopaedic Faculty of St. Louis University.

He was a Diplomate of The American Board of Orthopaedic Surgery, and a member of The American Academy of Orthopaedic Surgeons and the Clinical Orthopaedic Society.

His skill, good judgment, and technical excellence made him an outstanding surgeon. His warm, friendly personality and exceptional interest in human beings brought him, almost from the outset, a large practice.

Dr. Murphy interested many young men in orthopaedic surgery and helped them to secure good training. He stood always ready to assist them when they encountered personal or professional difficulties.

Helping people was his hobby; humility and charity were his virtues.

JACOB JOSHUA GOLUB

Dr. Jacob Joshua Golub, until recently the Medical Director and Executive Vice-President of the Hospital for Joint Diseases, passed away on September 22, 1953. From 1927 to 1952, he was the Medical Director of the Hospital for Joint Diseases and in that capacity he showed rare gifts as an administrator and hospital planner.

Dr. Golub was beloved and respected by the Medical Staff and by the Board of Directors of the Hospital for Joint Diseases. His sense of justice and his eagerness to advance orthopaedic surgery have been important factors in the development of the Hospital.

WALTER R. SIEVERS

Many orthopaedic surgeons in the New York area have learned with regret of the death of Walter R. Sievers, for many years in charge of the New York City office of Amsterdam Brothers, Inc. He was also connected with the Brace Shop of the Hospital for Joint Diseases. Mr. Sievers was greatly interested in the perfection and standardization of orthopaedic appliances. He helped to organize and was active in the work of the Prosthetic and Orthopaedic Appliance Industry, Inc., and served as Secretary of the American Board for Certification of that organization. Both doctors and laymen who had worked with him appreciated his high ideals and cooperative efforts. He made a real contribution to the development of orthopaedic appliances.

News Notes

The Twenty-first Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held at the Palmer House, Chicago, Illinois, January 23 to January 28, 1954.

The Ninth Annual Meeting of the **American Society for Surgery of the Hand** will be held at the Palmer House, Chicago, Illinois, on Friday, January 22, 1954.

Dr. Edward L. Compere became Chairman of the Department of Bone and Joint Surgery of Northwestern University, Chicago, on September 1, 1953.

At the request of the Israeli Government, Dr. Leo Mayer spent the month of April in Israel conducting clinics and seminars. He participated in the formation of Israel's Foundation for Infantile Paralysis and in the dedication of the Crippled Children's Home to be opened in Tel Aviv by the Israel Society for Crippled Children.

To his many friends and admirers, it will be a source of deep pleasure that Dr. Arthur Steindler, Professor Emeritus of Orthopaedic Surgery at The State University of Iowa, was elected to Honorary Membership in The British Orthopaedic Association.

Col. Ernest Allan Brav, M.C., U. S. A., has been assigned to Walter Reed Army Medical Center as Chief of the Orthopaedic Service of the Army Medical Center's Walter Reed Army Hospital component. He succeeds Col. August W. Spittler, M.C., U. S. A., who has been transferred to Brooke Army Medical Center, Fort Sam Houston, Texas.

The executive office of the Pan-Pacific Surgical Association announces that the **Sixth Pan-Pacific Surgical Congress** will be held in Honolulu, October 7–18, 1954.

Included in the scientific program will be sessions in all divisions of surgery and related fields, with papers presented by surgeons from the Pacific Area countries.

For further information concerning the Sixth Congress or membership in the Association, doctors may write to the Pan-Pacific Surgical Association, Suite 7, Young Building, Honolulu, Hawaii.

The Seventh Annual Meeting of the **American Academy for Cerebral Palsy** will be held on October 30 and 31, 1953, in Fort Worth, Texas, at the Western Hills Hotel. The scientific sessions are open to members of the medical or allied professions. Guests shall be required to pay a registration fee.

The establishment of two fellowships for clinical and experimental research has been announced by the Trustees of the **Jewish Sanitarium and Hospital for Chronic Diseases,** Brooklyn, New York. The fellowships, named in honor of the President of the Hospital, Mr. Isaac Albert, will be awarded during the fall of 1953. Application should be made to the Hospital Superintendent, Rutland Road and East 49th Street, Brooklyn, New York.

To acquaint children and their parents with what a hospital is like and what procedures children will experience during hospitalization, the Boston **Children's Hospital** has issued an attractive booklet entitled *Johnny Goes to the Hospital*. Johnny's hospital experiences are shown pictorially in color with the simplest, easy-to-understand legend below each illustration. The booklet succeeds admirably in its purpose and should be of considerable use to parents and hospitals throughout the country. It sells for $1.00 a copy, and on orders of six or more copies the price is seventy-five cents each. It may be purchased through the Public Relations Department of the Children's Medical Center, 300 Longwood Avenue, Boston 15, Massachusetts. All benefits from the sale of this booklet accrue to the Medical Center.

The **Ohio Orthopaedic Society** held its Annual Meeting in Lakewood and Elyria, Ohio, April 17 and 18, 1953. At the meeting held on Friday afternoon, April 17, at the Lakewood City Hospital, the following subjects were presented:

Unreducible Traumatic Dislocated Hips;
Defects in Shafts of Long Bones Following Sequestrectomies;
Review of the Use of Lorenzo Screws in Certain Intertrochanteric Hip Fractures;
By Paul H. Dubé, M.D.
Ischial-Pubic Osteochondrosis;
By Myron L. Pardee, M.D.
The Treatment of Infected Bone Cavities by Primary Bone Graft;
By Russell P. Rizzo, M.D.
Traction Casts in Comminuted Colles' Fractures;
By Donald E. Dial, M.D.
Intramedullary Nailing in Non-Union of Long Bones;
Epiphyseal Arrest;
End Results of Interesting Orthopaedic Problems;
By Glenn C. Barber, M.D.

Case presentations were made by Dr. Myron L. Pardee and Dr. Donald E. Dial.

At the meeting held on Saturday morning, April 18, at the Elyria Memorial Hospital, case presentations were made by Dr. Clarence Heyman, Dr. Charles Herndon, Dr. Joseph Strong, and Dr. George Bennett.

The President of the Society for the ensuing year is Dr. Theodore H. Vinke, Cincinnati, Ohio. Officers elected at this meeting are:

President-Elect: Dr. Herbert L. Brumbaugh, Dayton, Ohio;
Secretary-Treasurer: Dr. Donald I. Minning, Akron, Ohio.

The Sixth Congress of the **International Society of Orthopaedic Surgery and Traumatology** will be held in Bern, Switzerland, from August 30 to September 3, 1954.

Officers of the Society are as follows: Honorary President, Louis Ombrédanne; President, Sir Harry Platt; Vice-Presidents, Etienne Sorrel, José Valls; Treasurer, Charles Parisel.

The Congress will be held under the presidency of Prof. Etienne Sorrel, with Prof. Richard Scherb as Honorary President.

All correspondence should be addressed to the Secretary-General of the Society, Dr. Jean Delchef, 34, Rue Montoyer, Bruxelles, Belgium. Application should be made before May 31, 1954.

The tentative program includes such subjects as the treatment of scoliosis, physiology of sport, physiology of movement, chemical aspects of orthopaedic surgery, bone and joint tuberculosis, bone and joint pathology, and surgery of the hand. Visits to near-by hospitals, research centers, and other institutions have been scheduled, as well as excursions at the close of the Congress.

Arrangements for simultaneous translation (French-English, English-French) have been made through the Swiss branch of International Business Machines.

CORRECTIONS

The following errors appear in the article by Dr. William F. Thompson entitled "Blastomycosis of Bone. Report of a Case", which was published in *The Journal* for July 1953, Volume 35-A, pages 777–781:

The legend of Figure 3, page 779, refers to budding of the Blastomycetes. This should read "Photomicrograph (× 1000) of a section taken from the medial condyle of the left femur showing several Blastomycetes".

Under Discussion, page 780, lines 13 and 14, the words "as demonstrated in Figure 3" should be deleted.

Our attention has been called to an error in the abstract of the paper by Dr. L. L. Wiltse and Dr. R. H. Hall on "Use of Quick-Setting (Self-Curing) Acrylics in Orthopaedic Surgery" which appeared in the Proceedings of the Western Orthopedic Association in *The Journal of Bone and Joint Surgery*, Volume 35-A, page 788, July 1953. Lines 10 and 11 should read:

"Reactions to the acrylic were studied in rabbits and monkeys and it was found to produce no more reactions than Vitallium."

An error appears in the article by Dr. R. W. Bacorn and Dr. J. F. Kurtzke, "Colles' Fracture. A Study of Two Thousand Cases from the New York State Workmen's Compensation Board", *The Journal of Bone and Joint Surgery*, Volume 35-A, page 644, July 1953. The fifth line from the bottom of the page should read:

"The ratio in either year was the same as in the other, . . ."

Announcement

In 1954 the American Volume of *The Journal* will be published in six numbers instead of four, the two additional numbers appearing in June and December. It is hoped that by this arrangement *The Journal* may better meet the needs of its readers. The months of issue and the prices for 1954 will be found below.

American Volume — $13.00 or £4.0.0

Published in January, April, June, July, October, and December

British Volume — $10.00 or £3.0.0

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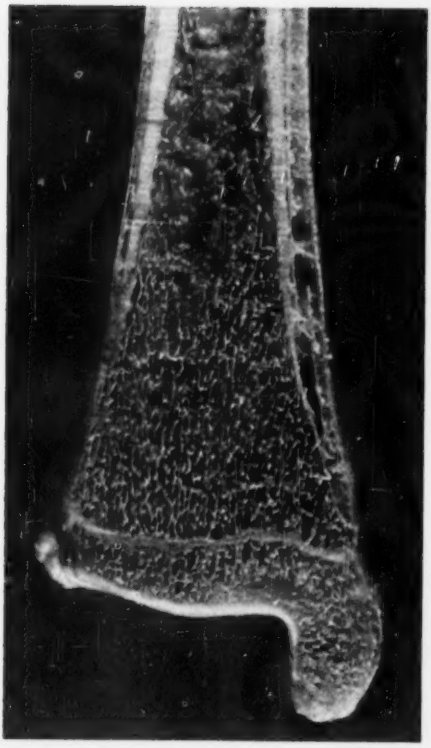

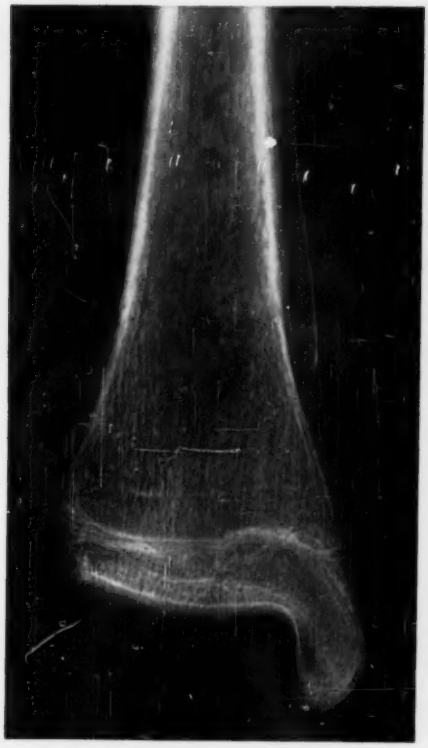

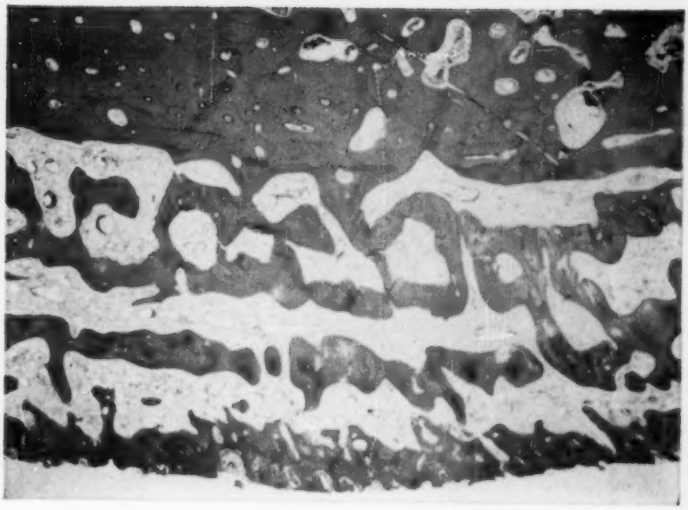

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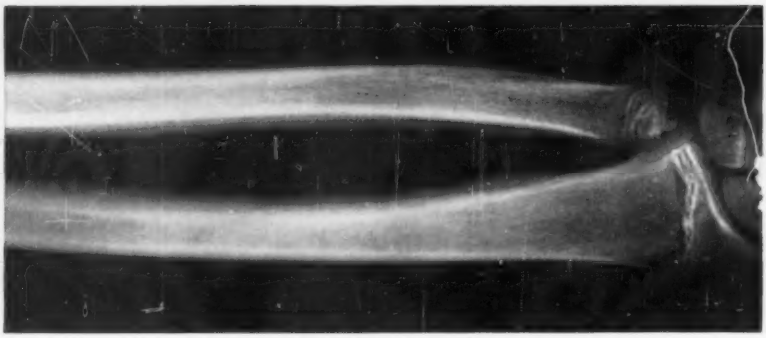

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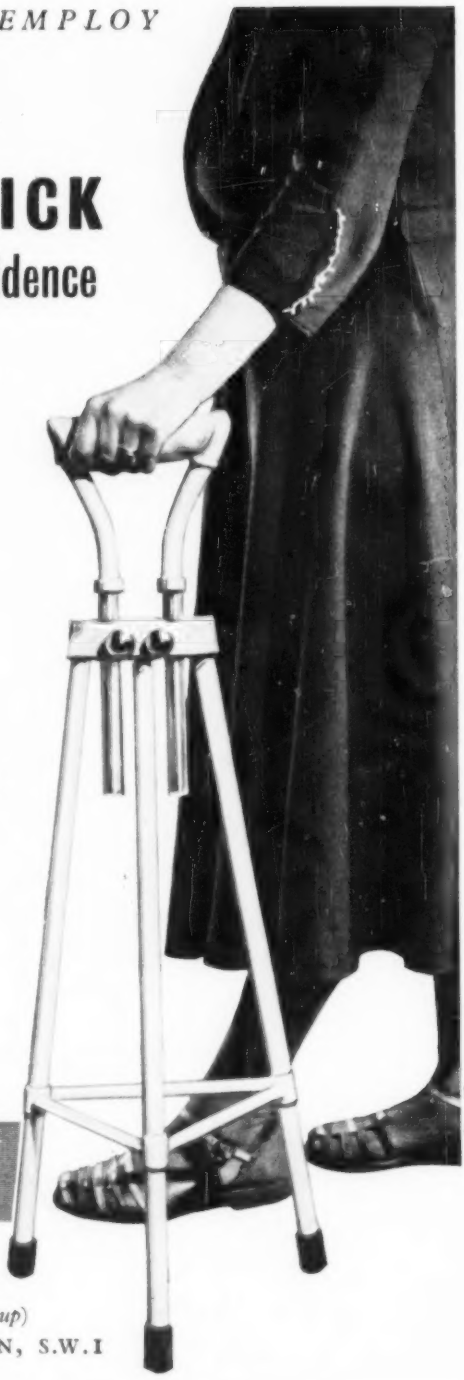

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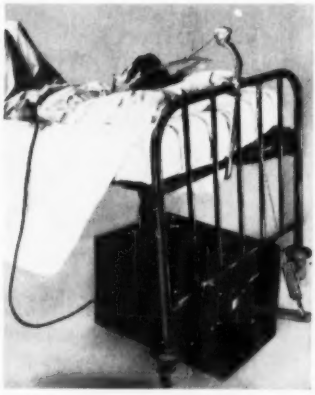

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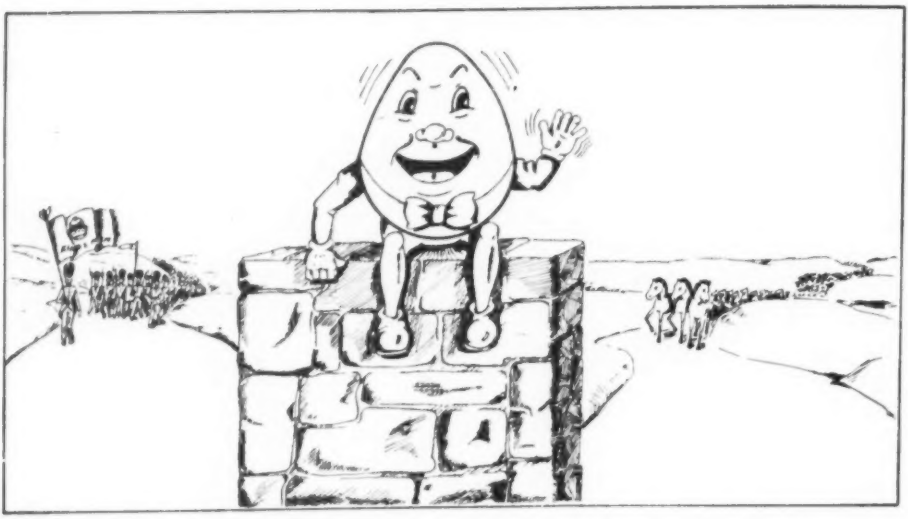

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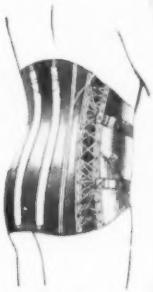

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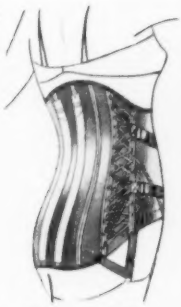

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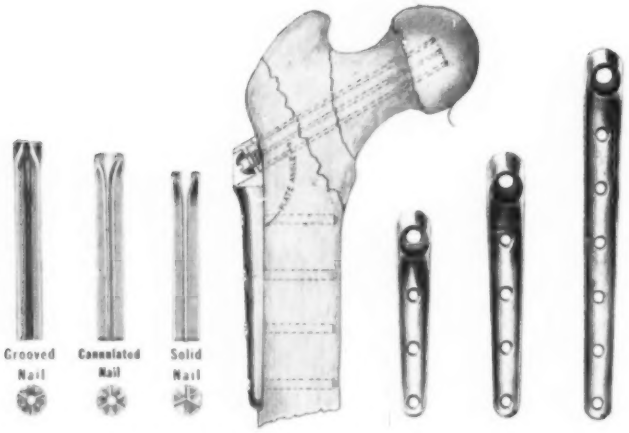

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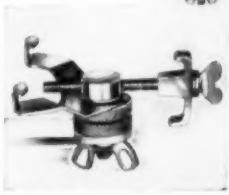

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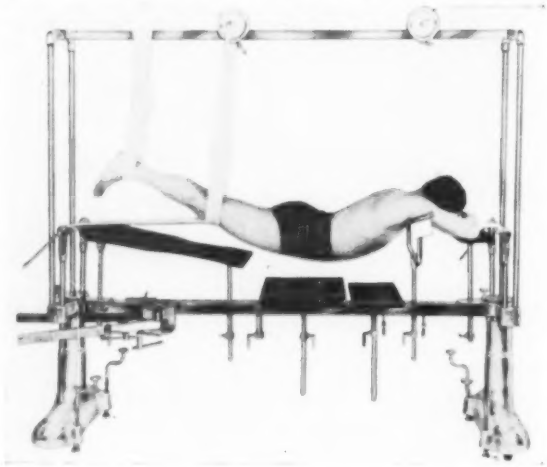

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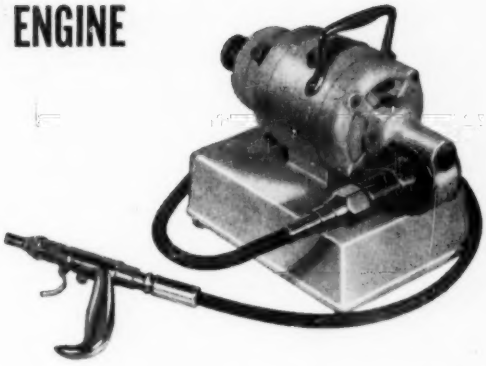

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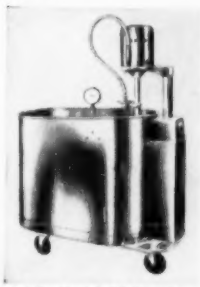

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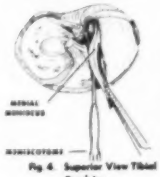

Fig. 4. Superior View Tibial Condyles

FIG. 4

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Fig. 3. Anterior View Medial Joint Space

FIG. 3

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Fig. 5

FIG. 5

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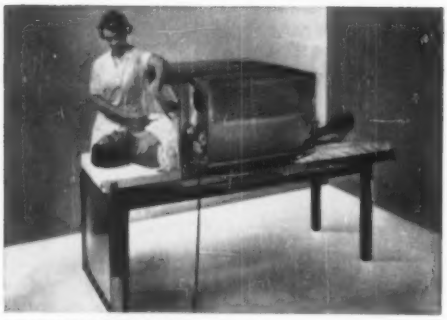

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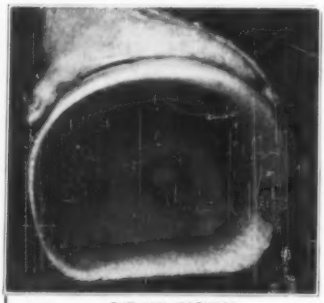

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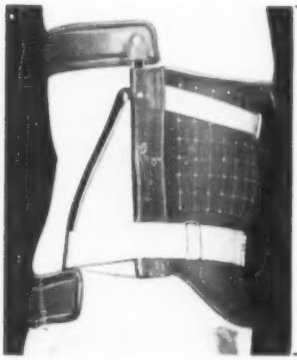

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List of Advertisers—October 1953

	PAGE
Acme Engineering Company, Inc.	20, 21
C. H. Alden Shoe Company	35
American Cyanamid Company	10
American Ossaeryl Company	33
Amsterdam Bros.	53
Astra Pharmaceutical Products, Inc.	8
Austenal Laboratories, Inc.	18, 19
Ayerst, McKenna & Harrison Limited	12, 36, 41
Bard-Parker Company, Inc.	25
Bauer & Black	23, 45
Rudolph Beaver	59
The Berivon Company	58
The Birtcher Corporation	27
Blairs Associate	38
Boston Artificial Limb Co., Inc.	65
Bowen and Company, Inc.	64
Brown Shoe Company	7
S. H. Camp and Company	24
Wilmot Castle Co.	16, 17
Chattanooga Pharmacal Co.	22
Gilbert Hyde Chick Company	62
C. & J. Clark Limited	67
Davis & Geck, Inc.	10
DePuy Manufacturing Co., Inc.	44
Eastman Kodak Company	51, 52
Fillauer Surgical Supplies, Inc.	61
Florida Brace Corporation	60
Freeman Manufacturing Company	59
Hanger Prostheses	26
House of Bidwell, Inc.	66
Johnson & Johnson	31
The Karmac Company	43
The Kendall Co.	23, 45
Kleistone Rubber Company, Inc.	34
J. B. Lippincott Company	57
Maurice J. Markell Shoe Co., Inc.	65
Medical Research Specialties	40
Merck & Co., Inc.	9
Miero X-Ray Recorder	67
Miller Brace Co.	66
Minnesota Orthopedic Services	67
Moore & Moore, Inc.	65
The C. V. Mosby Company	56
V. Mueller & Co.	63
The Orthopedic Appliance Co., Inc.	65
Orthpedic Equipment Co.	46
Orthopedic Frame Company	39
Pfizer Laboratories	11
J. A. Preston Corp.	62
Price Filler Machine & Mfg. Co.	60
Remploy Limited	54
Richards Manufacturing Company	4, 5, 6
The Ries Corporation	64
I. Sabel, Inc.	32
Chas. A. Schmidt Surg. Inst. Co.	42
J. Sklar Manufacturing Company	13
Surgical Appliance Industries, Inc.	37
Thompson Bros. Shoe Co.	32
The Tower Company, Inc.	47
Truform Anatomical Supports	37
The United Limb and Brace Co., Inc.	66
United States Manufacturing Company	28
The Upjohn Company	29
H. Weniger	67
Whitehall Electro Medical Company, Inc.	63
Winthrop-Stearns Inc.	30
Wright Manufacturing Co.	48, 49
Louis Yellin, Inc.	55
Zimmer Manufacturing Co.	14, 15

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OCTOBER 1953

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